10.5152/turkjnephrol.2023.23625

Original Article

Turkish Journal of Nephrology

A Survey-Based Study on Attitudes of The Clinicians Toward Contrast-Induced Nephropathy: Which Drugs to Discontinue?

Nuri Barış Hasbal[1], Sidar Copur[2], Dimitrie Siriopol[3], İbrahim Batuhan Peltek[4], Ali Mutlu[4], Bahar Tekin Çetin[2], Mehmet Kanbay[1]

[1]Division of Nephrology, Department of Internal Medicine, Koç University School of Medicine, Istanbul, Türkiye
[2]Department of Internal Medicine, Koç University School of Medicine, İstanbul, Türkiye
[3]Department of Nephrology, "Saint John the New" County, Hospital, Suceava, Romania and Stefan Cel Mare" University, Suceava, Romania
[4]Koç University School of Medicine, İstanbul, Türkiye

ABSTRACT

Objective: Contrast-induced nephropathy (CIN) is the third leading cause of iatrogenic acute kidney injury, affecting approximately 10% of patients. Multiple risk factors, including preexisting kidney disease, diabetes mellitus, and hypertension, have been described; however, there is no specific therapeutic approach. Also, there is no consensus on premedication or which drugs should be discontinued before the exposure, whether discontinued drugs should be restarted, and, if started, how long after the exposure. In this cross-sectional survey-based study, we aim to assess the attitudes of clinicians about the discontinuation of renin–angiotensin system (RAS) blockers, sodium–glucose cotransporter 2 (SGLT-2) inhibitors, loop diuretics, and metformin before contrast exposure to reduce the risk for CIN.

Method: We performed a survey-based study on clinicians, for which announcements were made through online platforms and national associations. Fully licensed physicians from the fields of internal medicine, cardiology, endocrinology, and nephrology with adult patients were included.

Results: We have included 517 clinicians—288 in internal medicine, 70 in endocrinology, 59 in cardiology, and 100 in nephrology. Most of the clinicians prefer the discontinuation of metformin before contrast exposure. About 51.5% of the nephrologists think that SGLT2 inhibitors should be stopped before exposure, as compared with only 25.9% of the cardiologists. The nephrologists were the main physicians who believed that RAS blockers should be stopped before the investigation (52.6%) and were more reluctant to restart rapidly after the exposure. The attitudes of the clinicians toward renin–angiotensin–aldosterone system blockers, loop diuretics, and SGLT-2 inhibitors are considerably variable.

Conclusion: The attitudes of clinicians regarding the discontinuation and reinitiation of such medications are clinician dependent. We hereby emphasize the need for future large-scale randomized clinical trials investigating this issue to reach a consensus in such a common clinical scenario.

Keywords: Acute kidney injury, contrast-induced nephropathy, diuretics, metformin, SGLT-2 inhibitors

Corresponding author: Nuri Barış Hasbal ✉ nhasbal@ku.edu.tr

Received: August 7, 2023 **Accepted:** August 31, 2023
Publication Date: January 5, 2024

Cite this article as: Hasbal NB, Copur S, Siriopol D, et al. A survey-based study on attitudes of the clinicians toward contrast-induced nephropathy: which drugs to discontinue?. *Turk J Nephrol.* 2024;33(1):40-46.

INTRODUCTION

Contrast-induced nephropathy (CIN), as the third leading cause of iatrogenic acute kidney injury (AKI), is a major concern with variable incidence depending on the definition; nevertheless, a large-scale meta-analysis study involving 259 studies has demonstrated an incidence rate of 9.06% with 0.52% requiring kidney replacement therapies.[1,2] The most widely accepted definition of CIN is an elevation of serum creatinine of more than 25% or ≥ 0.5 mg/dL from baseline within 48-72 hours of contrast exposure, while multiple risk factors, including preexisting kidney diseases, heart failure, diabetes mellitus, type and amount of contrast material, dyslipidemia, and certain medications, have been identified.[3-6] The management of CIN is mostly supportive care; therefore, the primary objective is preventive measures. Even though multiple agents, including sodium bicarbonate, intravenous hydration, statins, sodium–glucose transporter (SGLT) 2

inhibitors, fenoldopam, acetylcysteine, and ascorbic acids, have been proposed as potential candidates for risk reduction, only hydration has proven to be effective in large-scale studies.[3,7-9] Although the guidelines of the American College of Radiology and many other guidelines recommend the discontinuation of metformin and other nephrotoxic agents before either imaging or interventional studies involving contrast material, there is controversy regarding the discontinuation of SGLT-2 inhibitors and renin–angiotensin–aldosterone system (RAAS) blockers.[10] In this cross-sectional survey study, we aim to assess the attitudes of clinicians from different specialties about discontinuation and reinitiation of RAAS blockers, SGLT-2 inhibitors, loop diuretics, and metformin before contrast exposure to reduce the risk for CIN either due to diagnostic or interventional procedures.

METHODS

We have conducted an online survey study on fully licensed physicians internal medicine, cardiology, endocrinology, and nephrology. Our study was approved by Koc University Ethical Committee on Human Research, with the number 2023.140. IRB3.060 in April 2023. Before starting the survey, the online consent of the participants was obtained, and information was not recorded in a manner that could identify participants. The online survey is conducted between April 2023 and May 2023 in Türkiye.

Recruitment

Physicians were recruited by announcements via national associations of individual fields and social media platforms. Fully licensed physicians from t internal medicine, cardiology, endocrinology, and nephrology were included. We were unable to estimate the number of physicians who became aware of the survey study; therefore, we were unable to determine the response rate of our survey among physicians.

Questionnaire

The questionnaires were designed by inclusion of all authors through an iterative process and then modified independently. The survey is provided only in Turkish and primarily in the form of multiple-choice questions. Demographic data on participating physicians including age, gender, field of practice, and number of years in practice were obtained during the survey following the obtainment of informed consent of the participants.

Statistical Analysis

Variables were expressed as mean ± SD or as percent frequency, as appropriate. Comparisons between groups were performed with the one-way analysis of variance (ANOVA) followed by Tukey's test and the χ^2 or Fisher's exact test followed by the Bonferonni test for categorical data. All analyses were performed using Stata MP software, version 13 (Stata Statistical Software: Release 13. College Station, TX: StataCorp LLC). A two-tailed $P < .05$ was significant.

MAIN POINTS

- Contrast-induced nephropathy (CIN) is the third leading cause of iatrogenic acute kidney injury; there is no specific therapeutic approach. Also, there is no consensus on premedication or which drugs should be discontinued before the exposure, whether discontinued drugs should be restarted, and, if started, how long after the exposure.
- Most of the clinicians prefer the discontinuation of metformin before contrast exposure; 51.5% of the nephrologists think that sodium–glucose transporter (SGLT) 2 inhibitors should be stopped before the exposure, as compared with only 25.9% of the cardiologists.
- The attitudes of clinicians regarding the discontinuation and reinitiation of such medications are clinician dependent. We hereby emphasize the need for future large-scale randomized clinical trials investigating this issue to reach a consensus in such a common clinical scenario.

RESULTS

Main Characteristics of the Physicians Included in the Survey

Five hundred and seventeen physicians completed the survey—288 in internal medicine, 70 in endocrinology, 59 in cardiology, and 100 in nephrology. As shown in Table 1, the endocrinologists and nephrologists were older than the internists and cardiologists; consecutively, they also had a longer period in their specialty. The number of responses to a question is presented in Tables 2-5. Some items were not completed by all the respondents.

Attitudes and Beliefs on Stopping Sodium–Glucose Transporter 2 Inhibitors

Of the 504 responders, the majority believed that SGLT-2 inhibitors should not be stopped before contrast administration (60.2%). However, there was a significant difference in this belief between the different specialties (51.5% of the nephrologists that answered this question think that SGLT2 inhibitors should be stopped, as compared with only 25.9% of the cardiologists; see Table 2).

Most of the respondents believe that if SGLT-2 inhibitor should be stopped, the estimated glomerular filtration rate (eGFR) should be below 60 mL/min/1.73 m^2 (26.6%, 23.9%, and 35.4% if the eGFR is below 30, 45, or 60 mL/min/1.73 m^2 respectively), without any significant differences between specialties. Most of the physicians also believe that if it was to be stopped, this should be accomplished 24 or 48 hours before the investigation.

We noticed a disagreement between the specialties regarding when to restart the medication, with almost half of the nephrologists considering that SGLT2 inhibitors should be restarted after or more than 72 hours (Table 2).

Attitudes and Beliefs on Stopping Metformin

Most of the respondents believe that metformin should be stopped (67.8%), with the cardiologists (82.5%) being in most agreement with this attitude (see Table 3). There were significant

Table 1. Demographic and Clinical Characteristics of the Study Population

	All (n = 517)	Internal Medicine (n = 288)	Endocrinology (n = 70)	Cardiology (n = 59)	Nephrology (n = 100)	*P**
Age, years	36.5 ± 9.3	31.4 ± 5.9	45.9 ± 9.5	36.0 ± 7.1	45.1 ± 6.81 ± 6.8	**<.001**
Years in specialty, n (%)						**<.001**
<5 years	315 (60.9)	241 (83.7)	19 (27.1)	25 (42.4)	33 (30.0)	
5-10 years	62 (11.9)	20 (6.94)	15 (21.4)	8 (13.6)	19 (19.0)	
10-15 years	71 (13.7)	12 (4.2)	13 (18.6)	17 (28.8)	29 (29.0)	
>15 years	69 (13.4)	15 (5.2)	23 (32.9)	9 (15.3)	22 (22.0)	

Data are expressed as mean ± SD or percent frequency, as appropriate. Bold values are statistically significant.
**P* < 0.05 as mentioned in the Statistical analysis.

differences between the specialties when asked at what eGFR the medication should be stopped, with endocrinologists wanting to stop it at a higher eGFR. Additionally, there were differences in the timing of restarting it, with the nephrologists being more reluctant to restart the medication earlier after the contrast exposure.

Attitudes and Beliefs on Stopping Furosemide

As shown in Table 4, the nephrologists were the main respondents who believed this drug should be stopped before contrast exposure. There were no significant differences between the 4 specialties regarding the next two items. Again, the

Table 2. Attitudes and Beliefs on Stopping SGLT2 Inhibitors

	All	Internal Medicine	Endocrinology	Cardiology	Nephrology	*P**
Stop SGLTi, N (%)*	200 (39.7)	101 (39.5)	33 (47.1)	15 (25.9)	51 (51.5)	**.004**
If yes, at what eGFR should we stop SGLT2i? N (%)‡						
<30 mL/min/1.73 m^2	51 (26.6)	28 (29.5)	6 (18.2)	3 (21.4)	14 (28.0)	.47
<45 mL/min/1.73 m^2	46 (23.9)	26 (27.4)	6 (18.2)	0 (0.0)	14 (28.0)	
<60 mL/min/1.73 m^2	68 (35.4)	28 (29.5)	15 (45.5)	8 (57.1)	17 (34.0)	
<90 mL/min/1.73 m^2	15 (7.8)	7 (7.4)	3 (9.1)	2 (14.3)	3 (6.0)	
Always	12 (6.3)	6 (6.3)	3 (9.1)	1 (7.1)	2 (4.0)	
If yes, when we should stop SGLT2i? N (%)‡						
Exposure day	11 (5.7)	7 (7.4)	1 (3.0)	0 (0.0)	3 (6.0)	.29
24 hours before	80 (41.7)	45 (47.4)	14 (42.4)	2 (14.3)	19 (38.0)	
48 hours before	85 (44.3)	36 (37.9)	14 (42.4)	12 (85.7)	23 (46.0)	
72 hours before	12 (6.3)	6 (6.3)	3 (9.1)	0 (0.0)	3 (6.0)	
>72 hours before	4 (2.1)	1 (1.1)	1 (3.0)	0 (0.0)	2 (4.0)	
If yes, when we should restart SGLT2i? N (%)‡						
Exposure day	7 (3.7)	6 (6.3)	0 (0.0)	0 (0.0)	1 (2.0)	**<.001**
After 24 hours	80 (41.7)	50 (52.6)	20 (60.6)	3 (21.4)	7 (14.0)	
After 48 hours	60 (31.3)	25 (26.3)	10 (30.3)	8 (57.1)	17 (34.0)	
After 72 hours	26 (13.5)	9 (9.5)	2 (6.1)	3 (21.43)	12 (24.0)	
After >72 hours	18 (9.4)	5 (5.3)	1 (3.0)	0 (0.0)	12 (24.0)	
Never restart	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.0)	

Data are expressed as percent frequency. Bold values are statistically significant.
eGFR, estimated glomerular filtration rate; SGLT2i, sodium–glucose transporter 2 inhibitor.
*Only 504 answers—277 internists, 70 endocrinologists, 58 cardiologists, 99 nephrologists‡Only 192 answers—95 internists, 33 endocrinologists, 14 cardiologists, 50 nephrologists.

Table 3. Attitudes and Beliefs on Stopping Metformin

	All	Internal Medicine	Endocrinology	Cardiology	Nephrology	*P**
Stop metformin, N (%)*	334 (67.8)	170 (63.4)	54 (77.1)	47 (82.5)	63 (64.3)	**.01**
If yes, at what eGFR should we stop metformin? N (%)‡						
<30 mL/min/1.73 m^2	70 (21.3)	39 (23.5)	5 (9.4)	11 (23.4)	15 (23.8)	**.04**
<45 mL/min/1.73 m^2	63 (19.2)	41 (24.7)	5 (9.4)	5 (10.6)	12 (19.1)	
<60 mL/min/1.73 m^2	137 (41.6)	60 (36.1)	29 (54.7)	24 (51.1)	24 (38.1)	
<90 mL/min/1.73 m^2	34 (10.3)	13 (7.8)	10 (18.9)	5 (10.6)	6 (9.5)	
Always	25 (7.6)	13 (7.8)	5 (7.6)	2 (4.3)	6 (9.5)	
If yes, when we should stop metformin? N (%)‡						
Exposure day	21 (6.4)	11 (6.6)	2 (3.8)	5 (10.6)	3 (4.8)	.21
24 hours before	126 (38.3)	71 (42.8)	20 (37.7)	20 (42.6)	15 (23.8)	
48 hours before	158 (48.0)	71 (42.8)	29 (54.7)	21 (44.7)	37 (58.7)	
72 hours before	19 (5.8)	10 (6.0)	2 (3.8)	1 (2.1)	6 (9.5)	
>72 hours before	5 (1.5)	3 (1.8)	0 (0.0)	0 (0.0)	2 (3.2)	
If yes, when we should restart metformin? N (%)‡						
Exposure day	15 (4.6)	12 (7.2)	1 (1.9)	1 (2.1)	1 (1.6)	**<.001**
After 24 hours	142 (43.2)	82 (49.4)	31 (58.5)	25 (53.2)	4 (6.4)	
After 48 hours	106 (32.2)	50 (30.1)	16 (30.2)	15 (31.9)	25 (39.7)	
After 72 hours	44 (13.4)	15 (9.0)	4 (7.6)	5 (10.6)	20 (31.8)	
After >72 hours	19 (5.8)	6 (3.6)	1 (1.9)	1 (2.1)	11 (17.5)	
Never restart	3 (0.9)	1 (0.6)	0 (0.0)	0 (0.0)	2 (3.2)	

Data are expressed in percent frequency. Bold values are statistically significant.
eGFR, estimated glomerular filtration rate.
*Only 493 answers—268 internists, 70 endocrinologists, 57 cardiologists, 98 nephrologists. ‡Only 329 answers—166 internists, 53 endocrinologists, 47 cardiologists, 63 nephrologists.

nephrologists were more reluctant to restart the medication earlier after the contrast exposure.

Attitudes and Beliefs on Stopping Renin–Angiotensin System Inhibitors

Table 5 presents the responses to the questions related to this class of medication. Like the previous items, the nephrologists were the main physicians who believed that RAS inhibitors should be stopped before the investigation (52.6%) and were more reluctant to restart rapidly (more than 50% after or more than 72 hours) after the exposure. There were no other significant differences between the specialties, with the majority believing that the medication should be stopped at a lower eGFR and within 24 hours before the contrast administration.

DISCUSSION

We have performed a survey-based study among physicians regarding their behavior toward the discontinuation and reinitiation of various medications, including SGLT-2 inhibitors, RAS blockers, loop diuretics, and metformin, before contrast material exposure. Our results indicate low rates of discontinuation among all specialties with considerable interspecialty differences, with nephrologists most likely to discontinue any such drug and most likely to reinitiate later in the follow-up, demonstrating the lack of consensus and awareness.

Even though the exact underlying pathophysiology of CIN is unclear, multiple hypothetical pathophysiological mechanisms have been proposed. First, the administration of contrast material leads to a prolonged vasoconstrictive response with increased intrarenal vascular resistance and a decline in blood flow due to upregulation of adenosine and downregulation of nitric oxide following early and short vasodilatation.[11] Such hemodynamic alteration leads to a decline in the eGFR, as evident from Starling forces, along with a reduction in oxygen delivery to tubules.[12] Second, iodinated contrast material leads to osmotic diuresis, which enhances tubular reabsorption of water and electrolytes, which further elevates the oxygen and energy requirements of tubular cells.[13,14] Moreover, the concentration of the contrast medium within the tubular lumen leads

Table 4. Attitudes and Beliefs on Stopping Furosemide

	All	Internal Medicine	Endocrinology	Cardiology	Nephrology	*P*[*]
Stop furosemide, N (%)[*]	223 (45.9)	109 (41.6)	27 (39.7)	15 (26.3)	72 (73.5)	**<.001**
If yes, at what eGFR should we stop furosemide? N (%)[‡]						
<30 mL/min/1.73 m^2	64 (29.2)	34 (31.5)	2 (8.0)	5 (33.3)	23 (32.4)	.21
<45 mL/min/1.73 m^2	46 (21.0)	20 (18.5)	7 (28.0)	2 (13.3)	17 (23.9)	
<60 mL/min/1.73 m^2	68 (31.1)	31 (28.7)	11 (44.0)	8 (53.3)	18 (25.4)	
<90 mL/min/1.73 m^2	27 (12.3)	17 (15.7)	3 (12.0)	0 (0.0)	7 (9.9)	
Always	14 (6.4)	6 (5.6)	2 (8.0)	0 (0.0)	6 (8.5)	
If yes, when we should stop furosemide? N (%)[‡]						
Exposure day	50 (22.8)	34 (31.5)	3 (12.0)	1 (6.7)	12 (16.9)	.14
24 hours before	112 (51.1)	52 (48.2)	14 (56.0)	10 (66.7)	36 (50.7)	
48 hours before	53 (24.2)	21 (19.4)	7 (28.0)	4 (26.7)	21 (29.6)	
72 hours before	4 (1.8)	1 (0.9)	1 (4.0)	0 (0.0)	2 (2.8)	
If yes, when we should restart furosemide? N (%)[‡]						
Exposure day	6 (2.7)	3 (2.8)	0 (0.0)	1 (6.7)	2 (2.8)	**.001**
After 24 hours	114 (52.1)	70 (64.8)	19 (76.0)	6 (40.0)	19 (26.8)	
After 48 hours	51 (23.3)	20 (18.5)	4 (16.0)	5 (33.3)	22 (30.9)	
After 72 hours	29 (13.2)	11 (10.2)	1 (4.0)	1 (6.7)	16 (22.5)	
After >72 hours	18 (8.2)	4 (3.7)	1 (4.0)	2 (13.3)	11 (15.5)	
Never restart	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)	

Data are expressed in percent frequency. Bold values are statistically significant.
eGFR, estimated glomerular filtration rate.
*Only 485 answers—262 internists, 68 endocrinologists 57 cardiologists 98 nephrologists. ‡Only 219 answers—108 internists 25 endocrinologists, 15 cardiologists 71 nephrologists.

to an increase in the tubular fluid viscosity and thereby intratubular pressure.[15] Third, the contrast material has both direct and indirect toxic effects, mediated via reactive oxygen species and intratubular calcium influx, on tubular and endothelial cells, leading to apoptosis and necrosis.[16] Lastly, exposure to the contrast material leads to phosphorylation of Akt, inhibition of ERK-1/2, and alterations in the regulation of transcription factors such as forkhead box O 3a and STAT3, leading to necrosis and apoptosis.[17,18]

SGLT-2 inhibitors, via their inhibitory effect on glucose reabsorption at the S1 segment of the proximal tubule and leading to exposure of the S3 segment to higher glucose content, have been shown to be associated with osmotic nephropathy, a rare cause of drug-induced AKI as seen in intravenous immunoglobulin and iodinated contrast material.[19] Therefore, the concomitant use of SGLT-2 inhibitors and contrast material has the potential to aggravate CIN. Nevertheless, there are large-scale studies indicating the potential protective role of SGLT-2 inhibitors against CIN via anti-inflammatory, antioxidant, and antithrombotic properties.[20-22] Similarly, the role of RAS blockers in CIN remains inconclusive. Although multiple clinical studies indicate an increased risk of CIN with RAAS blockage continuation during contrast exposure via alterations in kidney hemodynamics, contradictory findings have been illustrated as well.[23-25] Our findings also indicate discrepancies between clinicians regarding their attitudes toward discontinuation and reinitiation of RAAS blockers and SGLT-2 inhibitors following contrast exposure. Therefore, we think that there is a need for future large-scale randomized clinical trials investigating such associations to reach a definitive consensus, potentially eliminating the interindividual and interspecialty differences in management of CIN.

Current guidelines have advocated for the discontinuation of metformin therapy before contrast exposure, especially for patients with eGFR below 30 mL/min/1.73 m^2, primarily due to potential concerns of accumulation that may lead to lactic acidosis.[26,27] However, our findings demonstrate low awareness regarding such issues. It is important to advocate via national and international associations to enhance awareness and alter clinical practice.

Table 5. Attitudes and Beliefs on Stopping RASi

	All	Internal Medicine	Endocrinology	Cardiology	Nephrology	*P*[*]
Stop RASi, N (%)[*]	198 (41.3)	116 (44.8)	13 (19.7)	18 (31.6)	51 (52.6)	**<.001**
If yes, at what eGFR should we stop RASi? N (%)‡						
<30 mL/min/1.73 m^2	44 (22.3)	28 (24.1)	1 (7.7)	3 (17.7)	12 (23.5)	.49
<45 mL/min/1.73 m^2	42 (21.3)	25 (21.6)	2 (15.4)	1 (5.9)	14 (27.5)	
<60 mL/min/1.73 m^2	69 (35.0)	41 (35.3)	6 (46.2)	10 (58.8)	12 (23.5)	
<90 mL/min/1.73 m^2	25 (12.7)	13 (11.2)	2 (15.4)	2 (11.8)	8 (15.7)	
Always	17 (8.6)	9 (7.8)	2 (15.4)	1 (5.9)	5 (9.8)	
If yes, when we should stop RASi? N (%)‡						
Exposure day	26 (13.2)	16 (13.8)	1 (7.7)	4 (23.5)	5 (9.8)	.21
24 hours before	106 (53.8)	68 (58.6)	8 (61.5)	7 (41.2)	23 (45.1)	
48 hours before	53 (26.9)	28 (24.1)	3 (23.1)	6 (35.3)	16 (31.4)	
72 hours before	9 (4.6)	4 (3.5)	1 (7.7)	0 (0.0)	4 (7.84)	
>72 hours before	3 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)	3 (5.9)	
If yes, when we should restart RASi? N (%)‡						
Exposure day	8 (4.1)	5 (4.3)	1 (7.7)	0 (0.0)	2 (3.9)	**.001**
After 24 hours	88 (44.7)	60 (51.7)	9 (69.2)	9 (52.9)	10 (19.6)	
After 48 hours	43 (21.8)	27 (23.3)	2 (15.4)	3 (17.7)	11 (21.6)	
After 72 hours	40 (20.3)	19 (16.4)	1 (7.7)	5 (29.4)	15 (29.4)	
After >72 hours	16 (8.1)	4 (3.5)	0 (0.0)	0 (0.0)	12 (23.5)	
Never restart	2 (1.0)	1 (0.9)	0 (0.0)	0 (0.0)	1 (1.9)	

Data are expressed in percent frequency. Bold values are statistically significant.
eGFR, Estimated glomerular filtration rate; RASi, renin–angiotensin system inhibitor.
*Only 479 answers—259 internists, 66 endocrinologists, 57 cardiologists 97 nephrologists. ‡Only 197 answers—116 internists, 13 endocrinologists, 17 cardiologists, 51 nephrologists

Our survey-based cross-sectional study has several important limitations. First, the study population, including the physicians recruited mostly via online announcements, may not be a homogeneous group, therefore limiting the generalizability of our results due to potential selection bias. Second, the survey-based study design of our study, primarily dependent upon the subjective responses of the participants, may overlook the differences between such answers and actual clinical practice. Lastly, our study has not distinguished between contrast media exposure for diagnostic or interventional purposes, despite higher rates of CIN observed in interventional studies, which may potentially account for the interspecialty discrepancies. However, our study is significant because it demonstrates the status of the awareness and attitude of physicians regarding the CIN risk associated with multiple medications.

CONCLUSION

The results of our survey-based study regarding the discontinuation and reinitiation of different medications to contrast exposure indicate considerable interspecialty differences and low rates of awareness. Our study is important because it demonstrates the need for future large-scale clinical trials to determine the need for discontinuation of each medication group and the need for actions to improve the awareness of clinicians.

Ethics Committee Approval: The approval for the study was provided by the Koç University Committee on Human Research.(Approval No:2023.140.IRB3.060, Date April 2023)

Informed Consent: Informed consents were obtained before the survey.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – N.H., S.C., M.K.; Design – N.H., S.C., M.K.; Supervision – N.H., D.S., B.C., M.K.; Resources – S.C., I.P., A.M.; Materials – S.C., I.P., A.M.; Data Collection and/or Processing – S.C., I.P., A.M.; Analysis and/or Interpretation – N.H., S.C., I.P., A.M.; Literature Search – S.C., I.P., A.M., B.C.; Writing Manuscript – S.C., I.P., A.M.; Critical Review – N.H., D.S., B.C., M.K.

Acknowledgments: The authors would like to thank to physicians participating in the study.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. Wu MY, Lo WC, Wu YC, et al. The incidence of contrast-induced nephropathy and the need for dialysis in patients receiving angiography: a systematic review and meta-analysis. *Front Med (Lausanne)*. 2022;9:862534. [CrossRef]
2. Rundback JH, Nahl D, Yoo V. Contrast-induced nephropathy. *J Vasc Surg*. 2011;54(2):575-579. [CrossRef]
3. Moitinho MS, Santos ES, Caixeta AM, Belasco AGDS, Barbosa DA, Fonseca CDD. Contrast-induced nephropathy in patients submitted to percutaneous coronary intervention: an integrative review. *Rev Bras Enferm*. 2020;73(suppl 5):e20200190. [CrossRef]
4. Hossain MA, Costanzo E, Cosentino J, et al. Contrast-induced nephropathy: pathophysiology, risk factors, and prevention. *Saudi J Kidney Dis Transpl*. 2018;29(1):1-9. [CrossRef]
5. Kanbay M, Siriopol D, Ozdogan E, et al. Serum osmolarity as a potential predictor for contrast-induced nephropathy following elective coronary angiography. *Int Urol Nephrol*. 2020;52(3):541-547. [CrossRef]
6. Aslan G, Afsar B, Sag AA, et al. The effect of urine pH and urinary uric acid levels on the development of contrast nephropathy. *Kidney Blood Press Res*. 2020;45(1):131-141. [CrossRef]
7. Subramaniam RM, Suarez-Cuervo C, Wilson RF, et al. Effectiveness of prevention strategies for contrast-induced nephropathy: a systematic review and meta-analysis. *Ann Intern Med*. 2016;164(6):406-416. [CrossRef]
8. Tao SM, Wichmann JL, Schoepf UJ, Fuller SR, Lu GM, Zhang LJ. Contrast-induced nephropathy in CT: incidence, risk factors and strategies for prevention. *Eur Radiol*. 2016;26(9):3310-3318. [CrossRef]
9. Kanbay M, Covic A, Coca SG, Turgut F, Akcay A, Parikh CR. Sodium bicarbonate for the prevention of contrast-induced nephropathy: a meta-analysis of 17 randomized trials. *Int Urol Nephrol*. 2009;41(3):617-627. [CrossRef]
10. Kodzwa R. ACR manual on contrast media: 2018 updates. *Radiol Technol*. 2019;91(1):97-100.
11. Andreucci M, Faga T, Pisani A, Sabbatini M, Russo D, Michael A. Prevention of contrast-induced nephropathy through a knowledge of its pathogenesis and risk factors. *ScientificWorldJournal*. 2014;2014:823169. [CrossRef]
12. Heyman SN, Rosen S, Rosenberger C. Renal parenchymal hypoxia, hypoxia adaptation, and the pathogenesis of radiocontrast nephropathy. *Clin J Am Soc Nephrol*. 2008;3(1):288-296. [CrossRef]
13. Bucher AM, De Cecco CN, Schoepf UJ, et al. Is contrast medium osmolality a causal factor for contrast-induced nephropathy? *BioMed Res Int*. 2014;2014:931413. [CrossRef]
14. Andreucci M, Faga T, Pisani A, Sabbatini M, Michael A. Pathogenesis of acute renal failure induced by iodinated radiographic contrast media. *Austin J Nephrol Hypertens*. 2014;1(1):1005.
15. Seeliger E, Lenhard DC, Persson PB. Contrast media viscosity versus osmolality in kidney injury: lessons from animal studies. *BioMed Res Int*. 2014;2014:358136. [CrossRef]
16. Heyman SN, Rosen S, Khamaisi M, Idée JM, Rosenberger C. Reactive oxygen species and the pathogenesis of radiocontrast-induced nephropathy. *Invest Radiol*. 2010;45(4):188-195. [CrossRef]
17. Andreucci M, Fuiano G, Presta P, et al. Radiocontrast media cause dephosphorylation of Akt and downstream signaling targets in human renal proximal tubular cells. *Biochem Pharmacol*. 2006;72(10):1334-1342. [CrossRef]
18. Andreucci M, Lucisano G, Faga T, et al. Differential activation of signaling pathways involved in cell death, survival and inflammation by radiocontrast media in human renal proximal tubular cells. *Toxicol Sci*. 2011;119(2):408-416. [CrossRef]
19. Perazella MA, Juncos LA. Drug-induced osmotic nephropathy: add SGLT2-inhibitors to the list? *Kidney360*. 2022;3(3):550-553. [CrossRef]
20. Huang X, Guo X, Yan G, et al. Dapagliflozin attenuates contrast-induced acute kidney injury by regulating the HIF-1α/HE4/NF-κB pathway. *J Cardiovasc Pharmacol*. 2022;79(6):904-913. [CrossRef]
21. Nusca A, Piccirillo F, Viscusi MM, et al. Contrast-induced acute kidney injury in diabetic patients and SGLT-2 inhibitors: a preventive opportunity or promoting element? *J Cardiovasc Pharmacol*. 2022;80(5):661-671. [CrossRef]
22. Cowie MR, Fisher M. SGLT2 inhibitors: mechanisms of cardiovascular benefit beyond glycaemic control. *Nat Rev Cardiol*. 2020;17(12):761-772. [CrossRef]
23. Kobori H, Mori H, Masaki T, Nishiyama A. Angiotensin II blockade and renal protection. *Curr Pharm Des*. 2013;19(17):3033-3042. [CrossRef]
24. Goo JJ, Kim JJ, Kang JH, et al. Effect of renin-angiotensin-system blockers on contrast-medium-induced acute kidney injury after coronary angiography. *Korean J Intern Med*. 2014;29(2):203-209. [CrossRef]
25. Yamada T, Fujisaki T, Chopra N, et al. Effect of renin-angiotensin system blockers on contrast-induced acute kidney injury in patients with normal or mild-to-moderate reduced kidney function undergoing coronary angiography: a systematic review and meta-analysis. *Clin Nephrol*. 2020;94(5):227-236. [CrossRef]
26. Goergen SK, Rumbold G, Compton G, Harris C. Systematic review of current guidelines, and their evidence base, on risk of lactic acidosis after administration of contrast medium for patients receiving metformin. *Radiology*. 2010;254(1):261-269. [CrossRef]
27. Landewé-Cleuren S, van Zwam WH, de Bruin TW, de Haan M. Prevention of lactic acidosis due to metformin intoxication in contrast media nephropathy. *Ned Tijdschr Geneeskd*. 2000;144(40):1903-1905.