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Дозвіл комісії з біоетики щодо проведення досліджень: Письмову поінформовану згоду було отримано від пацієнта, який брав участь у дослідженні.

Фінансування: автори декларують відсутність фінансування.

Гостра ниркова недостатність унаслідок використання внутрішньовенних контрастних речовин для медичних радіологічних втручань: поширеність та визначення факторів впливу

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Медико-рентгенологічні діагностичні або терапевтичні втручання широко застосовуються для звичних медичних процедур у пацієнтів різного віку. Водночас вплив рентгеноконтрастних речовин усе частіше вважають причиною гострої ниркової недостатності (ГНН), яка скорочує тривалість життя пацієнтів. Метою цього дослідження було вивчити відмінності в поширеності та чинниках впливу у випадку ГНН та її підтипів у пацієнтів після рентгенологічних діагностичних або терапевтичних втручань із застосуванням внутрішньовенних контрастних речовин, зокрема комп'ютерної томографії (КТ), ангіографії та магнітно-резонансної томографії (МРТ). У цьому обсерваційному дослідженні взяли участь 8060 пацієнтів (з великої нефрологічної клініки в Берліні, Німеччина). ГНН було діагностовано відповідно до критеріїв AKIN. Загальна поширеність ГНН становила 9%. Переважали пацієнти з ГНН віком 60–79 років (51%) і 80–100 років (37%) відповідно. ГНН була суттєво пов'язана з використанням йодованих рентгеноконтрастних речовин (94%) після КТ й ангіографії, а 92% пацієнтів мали критерії AKIN

1. Поширеність AKIN 2 та AKIN 3 була вищою серед пацієнтів після МРТ із нейодованими рентгеноконтрастними речовинами. За підсумками отриманих результатів частота ГНН серед пацієнтів після внутрішньовенного введення контрастної речовини для лікувального рентгенологічного втручання є низькою. Було виявлено, що відмінності в поширеності ГНН пов'язані з віком і типом використаних контрастних речовин.

Ключові слова: гостра ниркова недостатність, йодовані рентгеноконтрастні речовини, нейодовані рентгеноконтрастні речовини, нефрологія, радіологія, AKIN

Acute kidney injury induced with intravenous contrast agents for medical radiological interventions: Incidence and determination of the influencing factors

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Medical radiological diagnostic or therapeutic interventions are widely used as routine medical procedures in patients of all ages. At the same time, radiographic contrast agent exposure has been increasingly blamed for acute kidney injury (AKI) which reduces patients' quality of life. This study aimed to explore the differences in incidence and influencing factors for AKI and its subtypes among patients after radiological diagnostic or therapeutic interventions with intravenous contrast agents, including computed tomography (CT), angiography, and magnetic resonance imaging (MRI). This observational study included 8060 patients (from the large nephrological clinic in Berlin, Germany) and AKI was diagnosed according to AKIN criteria ranging. The pooled prevalence of AKI was 9 %. Patients with AKI aged 60–79 years (51%) and 80–100 years (37%), respectively, were predominant. AKI was significantly associated with using iodinated radiographic contrast agents (94 %) after CT and angiography and 92 % of patients had AKIN 1. The prevalence of AKIN 2 and AKIN 3 was higher among patients after MRI with non-iodinated radiographic contrast agents. To sum up obtained results, the incidence of AKI among patients after intravenous contrast agents for medical radiological interventions is low. Differences in the prevalence of AKI were found to be related to age and the type of contrast agents used.

Keywords: Acute kidney injury, Iodinated radiographic contrast agents Non-iodinated radiographic contrast agent, Nephrology, Radiology, AKIN

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Medical radiographic diagnostic or therapeutic interventions are widely used as routine medical procedures in patients of all ages. At the same time, radiographic contrast agent exposure has been increasingly blamed for acute kidney injury (AKI) which reduces patients' quality of life. Acute kidney injury (AKI) is a disease that requires intensive treatment. For a long time, it has been considered that using iodinated and non-iodinated contrast agents for radiographic diagnostic imaging and/or medical interventions may adversely affect patients' renal function or cause acute kidney injury (AKI) [1, 2]. Lately, the matter of possible numerous side effects of contrast agents, including AKI induction [3-5], has been causing interdisciplinary discussions among physicians of different specialities [6, 7]. Many research groups have shown controversial results in terms of contrast agent application for patients with kidney disease [8, 9]. Therefore, determining the prevalence and factors influencing the occurrence of AKI in patients with kidney disease who undergo medical diagnostic and/or therapeutic radiological interventions based on the use of contrast agents is an urgent medical problem. These circumstances caused the aim of our research: to study the effects of iodinated and non-iodinated contrast agents used for radiographic visual and therapeutic interventions for patients in the hospital serving numerous patients with nephrological diseases.

The study group consisted of patients treated at the St. Joseph Hospital in Berlin-Tempelhof (Germany) for the past 5 years (2014-2019). A total of 8060 patients who underwent radiographic examinations (computed tomography (CT), angiography and magnetic resonance imaging (MRI)) were analyzed to assess the activity of various organs and systems and/or in view of prescribed medical interventions through the administration of iodinated and non-iodinated contrast agents. Signs of acute kidney injury were assessed based on the study of clinical parameters of renal function in terms of creatinine content before and after the diagnostic imaging with contrast agents. Subsequently, the results were interpreted according to KDIGO (Kidney Disease: Improving Global Outcomes) clinical guidelines [10] using clinical recommendation criteria elaborated by the AKIN (Acute

Kidney Injury Network) working group and highlighting three stages of acute kidney injury: AKIN 1, AKIN 2, AKIN 3 [11] (Table 1). We considered that if the patient's dynamics of creatinine content exceeded the baseline by 1.3 times after medical radiographic intervention with intravenous administration of contrast agents, there was a risk of AKI.

Table 1.

Determining stages of acute kidney injury based on AKIN criteria

AKIN stage	Creatinine content in blood serum	Urine output
1	1.5 – 1.9 * from the baseline or $\geq 0,3$ mg/dl	< 0.5 ml/kg during 6-12 hours
2	2.0 – 2.9 * from the baseline	< 0.5 ml/kg during > 12 hours
3	3.0 * from the baseline or ≥ 4 mg/dl or dialysis	< 0.3 ml/kg/hour during ≥ 24 hours or anuria during ≥ 12 hours

The general age characteristics of patients involved in the study group are presented in Table 2. Patients aged 60-79 were the most numerous in the study group – 52%, followed by the 60-79 age group – 38%.

Table 2

Distribution of patients in the observation group by age

Age (years)	Number of patients
0-19	11
20-39	85
40-59	698
60-79	4205
80-100	3051
100+	10

The results of studies of creatinine content dynamics in the blood serum of patients ($n = 8060$, of which 53% were women and 47% men) before the procedure of contrast agent administration, which we considered basal values, and after radiographic procedures, based on which the AKI was diagnosed, are presented in Figure 1. After radiographic studies using contrast agents, 2890 patients in the study group were found to have creatinine content less than 1.3 from the baseline; in the remaining patients ($n = 3958$), creatinine content was greater than 1.3 mg/dl, and in

1212 patients, it was more than 2.5 mg/dl (Figure 1.A). Based on AKIN criteria, it was established that after the administration of the contrast agent used to conduct radiographic studies, signs of kidney injury were absent in 91% (7364 cases) of patients. Acute kidney injury developed only in 9% of patients (696 cases out of 8060) (Figure 1.B).

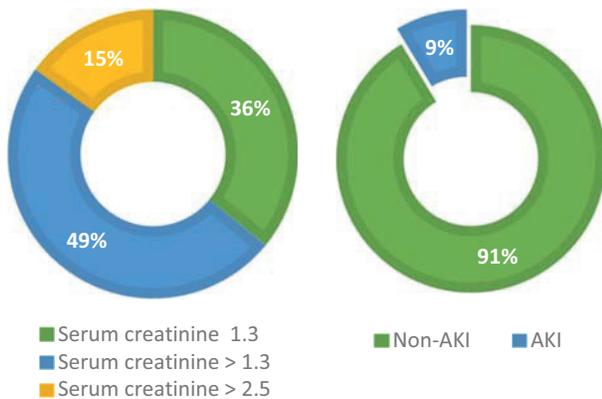


Figure 1.A (left): the assessment of kidney function through the investigation of basal serum creatinine level in patients (n=8060); B (right): Data of signs of acute kidney injury (AKI) in patients based on AKIN criteria

We have established the age characteristics of AKI after the application of contrast agents. Age differences in the prevalence of AKI are presented in Table. 3. It shows that manifestations of AKI were most common in the group of patients aged 60-79 and amounted to 51% and in persons aged 80-100 – 37% of the total number of patients (Table 3).

Table 3

Age differences in the prevalence of acute kidney injury

Age (years)	Number	AKIN 1	AKIN 2	AKIN 3
0-19	1	1	-	-
20-39	5	5	-	-
40-59	55	50	2	3
60-79	355	323	25	7
80-100	279	260	16	3
100+	1	-	1	-

The increased susceptibility to AKI in this category of patients can be explained by age-related changes in renal function and comorbidities. In the 60-79 age group, manifestations of kidney injury were most pronounced and had the greatest extent of

the signs of AKIN 2 and AKIN 3.

Subsequently, we found that in 94% of patients with AKI, renal impairment was caused by radiographic studies using iodine-containing substances during CT and angiography. Patients who were administered non-iodinated substances (6%) during MRI with a contrast agent containing gadolinium, had signs of kidney injury according to AKIN 2 and AKIN 3 criteria.

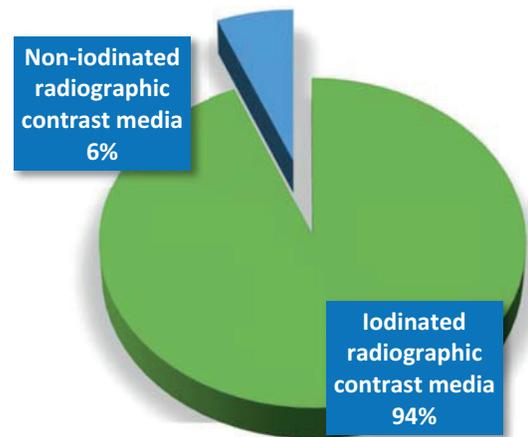


Figure 2. The incidence of acute kidney injury signs in patients (n=8060) after using iodinated radiographic contrast agents and non-iodinated contrast agents

The next stage of our research was to study the degree of kidney injury based on AKIN criteria among patients who were administered iodinated contrast agents and had signs of AKI. The vast majority of these patients (92%) had signs of AKIN-1, but in 44 cases, the AKIN-2 stage was observed, and in 13 out of 8060 cases, the AKIN-3 stage was diagnosed (Fig. 2B).

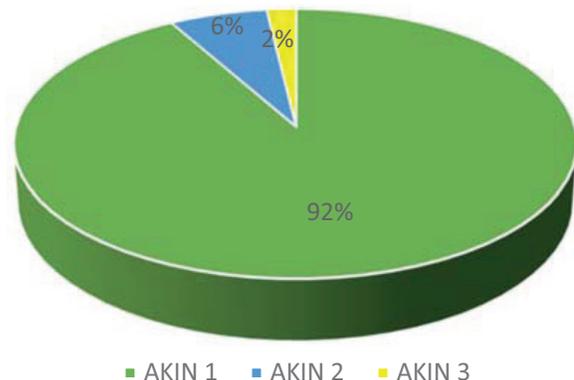


Figure 3. The degree of contrast-induced acute kidney

injury (CI-AKI) based on AKIN classification among patients aged 60-80 with AKIN 1, AKIN 2, AKIN 3

The obtained results allow concluding that the prevalence of AKI after medical radiographic studies using contrast agents is low, as it was observed in only 9% of patients from the total number of persons included in the study group. Most cases of acute kidney injury have been reported in people aged 60-79. Manifestations of the acute kidney injury meeting AKIN 2 and AKIN 3 criteria, were found in only 1% of all patients diagnosed with AKI. We were unable to establish significant differences between the effects of iodinated and non-iodinated

contrast agents in the occurrence of AKI, as both groups had an almost identical percentage of patients with respective criteria. However, in the case of the administration of non-iodinated contrast agents for radiographic imaging, acute kidney injury based on AKIN 2 and AKIN 3 criteria was more common.

Study limitations include the conduct of a retrospective analysis of the electronic database of patients for 2015-2019. In the future, the experimental group of patients will be supplemented with data for 2019-2022 and statistical analysis will be conducted to account for significant findings and 95% confidence

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