mellitus. Cardiovascular Diabetology. 2020;19(1):1-3. doi: https://doi.org/10.1186/S12933-020-01157-7

13. Yang YL, Wu CH, Hsu PF, Chen SC, Huang SS, Chan WL, et al. Systemic immune-inflammation index (SII) predicted clinical outcome in patients with coronary artery disease. Eur J Clin Invest. 2020;50(5):e13230. doi: https://doi.org/10.1111/ECI.13230

14. Ji Z, Liu G, Guo J, Zhang R, Su Y, Carvalho A, et al. The Neutrophil-to-Lymphocyte Ratio Is an Important Indicator Predicting In-Hospital Death in AMI Patients. Front Cardiovasc Med. 2021;8:1138. doi: https://doi.org/10.3389/fcvm.2021.706852

15. Tashchuk VK, Bota RA, Salama MA. [Dynamics of leukocyte inflammatory markers in patients with ST-segment elevation myocardial infarction depending on left ventricular ejection fraction]. Pathology. 2022;19(3):195-200. Ukrainian. doi: https://doi.org/10.14739/2310-1237.2022.3.267268

16. Çelik MC, Karayiğit O, Ozkan C, Dolu AK, Kalçık M. Relationship Between Systemic Inflammation Index and No-Reflow Phenomenon in Patients With ST-Segment Elevation Myocardial Infarction. Angiology. 2023;74(4):387-94. doi: https://doi.org/10.1177/00033197221115562

17. Kayama Y, Raaz U, Jagger A, Adam M, Schellinger IN, Sakamoto M, et al. Diabetic Cardiovascular Disease Induced by Oxidative Stress. Int J Mol Sci. 2015;16(10):25234-63. doi: https://doi.org/10.3390/IJMS161025234

18. Jha D, Goenka L, Ramamoorthy T, Sharma M, Dhandapani VE, George M. Prognostic role of soluble ST2 in acute coronary syndrome with diabetes. Eur J Clin Invest. 2018;48(9):e12994. doi: https://doi.org/10.1111/ECI.12994

19. Zhuravlova MI. [The relationship between calprotectin and parameters of lipid and carbohydrate metabolism, anthropometric and inflammatory parameters in patients with acute myocardial infarction and diabetes mellitus type 2]. Current issues of modern medicine. 2019;19(2):16-8. Ukrainian. doi: https://doi.org/10.31718/2077-1096.19.2.16

20. Hilova YaV. [Biomarker of myocardial stress sST2 in patients with acute myocardial infarction with ST-segment elevation]. Ukrainian Journal of Medicine, Biology and Sports. 2018;3(2):55-9. Ukrainian. doi: https://doi.org/10.26693/jmbs03.02.055

21. Bilovol OM, Knyazkova II. [Towards the use of biomarkers in special patient subgroups: a focus on soluble ST2]. Medicine of Ukraine. 2022;265-266(9-10):24-8. Ukrainian. doi: https://doi.org/10.37987/1997-9894.2022.9-10(265-6).271848

Стаття надійшла до редакції
12.04.2023

UDC 616.61-07-084:616.132.2-008.6-085 https://doi.org/10.26641/2307-0404.2023.4.294013

PREVENTION OF CONTRAST-INDUCED NEPHROPATHY DURING INTERVENTIONAL TREATMENT OF ACUTE CORONARY SYNDROME

L.O. Miakinkova,
T.I. Yarmola,
G.L. Pustovoit,
Iu.A. Kostrikova,
B.O. Pysana,
V.V. Talash *

Poltava State Medical University
Shevchenko str. 23, Poltava, 36000, Ukraine
Полтавський державний медичний університет
вул. Шевченка, 23, Полтава, 36000, Україна
**e-mail: viktorya.talash@gmail.com*

Цитування: Медичні перспективи. 2023. Т. 28, № 4. С. 49-57
Cited: Medicni perspektivi. 2023;28(4):49-57

Key words: *contrast-induced nephropathy, urgent percutaneous coronary intervention, acute coronary syndrome, chronic kidney disease*
Ключові слова: *контраст-індукована нефропатія, ургентне черезшкірне коронарне втручання, гострий коронарний синдром, хронічна хвороба нирок*

Abstract. Prevention of contrast-induced nephropathy during interventional treatment of acute coronary syndrome. Miakinkova L.O., Yarmola T.I., Pustovoit G.L., Kostrikova Iu.A., Pysana B.O., Talash V.V. *The aim of the work was to determine the risk factors of contrast-induced nephropathy in patients with acute coronary syndrome and to evaluate the effectiveness of methods of its prevention. There were examined 62 patients admitted to the interventional cardiology department during 9 months of routine practice with a diagnosis of acute coronary syndrome and concomitant chronic kidney disease. Among them, 56.45% have diabetic nephropathy, 21% – hypertensive nephropathy, 19.35% – chronic pyelonephritis, 3.2% – gouty nephropathy. According to the stages of chronic kidney disease: I stage – 8.1%, II stage – 46.8%, III A stage – 30.6%, III B stage – 14.5% of patients. The control group consisted of 32 patients with acute coronary syndrome without kidney pathology. All patients underwent urgent percutaneous coronary intervention with a water-soluble low-osmolarity radiocontrast medium. The risk of contrast-induced nephropathy was determined according to the Mehran scale. Contrast-induced nephropathy was diagnosed by an increase in serum creatinine by >25% over 24-48 hours. Prevention of contrast-induced nephropathy according to existing recommendations was carried out by prescribing early statin therapy and diuresis-controlled combined hydration in 22 patients with concomitant chronic kidney disease. Mathematical processing was performed using Statistica 8.0 software (StatSoft Inc, USA). Patients with chronic kidney disease had a high and very high risk of contrast-induced nephropathy in 19.4% and 3.2% of cases, among them in 91.6% high, and in 100% – very high-risk contrast-induced nephropathy developed. Patients in the control group had a low to moderate risk, none of them developed contrast-induced nephropathy. It has been shown that the risk of contrast-induced nephropathy depends on the stage of chronic kidney disease and is associated with a decrease in the ejection fraction of the left ventricle (≤40%), acute left ventricle failure of the III and IV classes according to Killip, a decrease in diuresis up to ≤0.6 ml/h/kg in the first 12-24 hours after urgent percutaneous coronary intervention; taking metformin 6-12 hours before the administration of the X-ray contrast medium and the glomerular filtration rate ≤45 ml/min./1.73 m^2. In patients who underwent prevention of contrast-induced nephropathy in its entirety, its development was not registered.*

Реферат. Профілактика контраст-індукованої нефропатії при інтервенційному лікуванні гострого коронарного синдрому. М'якінькова Л.О., Ярмола Т.І., Пустовойт Г.Л., Кострікова Ю.А., Писана Б.О., Талаш В.В. *Метою роботи було визначити фактори ризику контраст-індукованої нефропатії в пацієнтів із гострим коронарним синдромом та оцінити ефективність методів її профілактики. Обстежено 62 пацієнти, що надійшли у відділення інтервенційної кардіології протягом 9 місяців рутинної практики з діагнозом гострий коронарний синдром та супутньою хронічною хворобою нирок. Серед них 56,45% хворих на діабетичну нефропатію, 21% – гіпертензивну нефропатію, 19,35% – хронічний пієлонефрит, 3,2% – подагричну нефропатію. За стадіями хронічної хвороби нирок: I стадія – 8,1%, II стадія – 46,8%, III A стадія – 30,6%, III B стадія – 14,5% хворих. Контрольну групу склали 32 пацієнти з гострим коронарним синдромом без патології нирок. Усім пацієнтам проводилось ургентне черезшкірне коронарне втручання з використанням водорозчинного низькоосмолярного рентгеноконтрастного препарату. Ризик виникнення контраст-індукованої нефропатії визначали за шкалою Mehran. Контраст-індуковану нефропатію діагностували за підвищенням сироваткового креатиніну впродовж 24-48 годин на >25%. Профілактика контраст-індукованої нефропатії згідно з чинними рекомендаціями проводилась шляхом призначення ранньої статинотерапії та контрольованої за діурезом комбінованої гідратації 22 пацієнтам із супутньою хронічною хворобою нирок. Математична обробка виконувалася з використанням програмного забезпечення Statistica 8.0 (StatSoft Inc, США). Пацієнти з хронічною хворобою нирок мали високий та дуже високий ризик контраст-індукованої нефропатії в 19,4% та 3,2% випадків, серед них у 91,6% випадків високого та 100% – дуже високого ризику розвинулась контраст-індукована нефропатія. Пацієнти контрольної групи мали низький та помірний ризик, у жодного з них не розвинулася контраст-індукована нефропатія. Показано, що ризик виникнення контраст-індукованої нефропатії залежить від стадії хронічної хвороби нирок та асоційований зі зниженням фракції викиду лівого шлуночка (≤40%), гострою лівошлуночковою недостатністю III та IV класу за Killip, зменшенням діурезу в перші 12-24 години після ургентного черезшкірного коронарного втручання до ≤0,6 мл/год/кг; прийому метформіну за 6-12 годин перед введенням рентгенконтрастного препарату та швидкістю клубочкової фільтрації ≤45 мл/хв/1,73 м^2. У пацієнтів, яким була проведена профілактика контраст-індукованої нефропатії в повному обсязі, її розвиток не зареєстрований.*

Cardiovascular disease (CVD) is the leading cause of mortality in Ukraine (67.3%), with dominating coronary heart disease (68.8%) [1]. The prognosis for patients with coronary artery disease depends mainly on the progression of coronary atherosclerosis [2]. Acute coronary syndrome (ACS) is a form of coronary heart disease (CHD) that usually develops as a result of occlusion of coronary vessels and leads to loss of viable myocardium. The use of urgent percutaneous coronary intervention (PCI) in the first 72 hours after the onset of ACS increased from 9% in 1995 to 60% in 2015, which reduced 6-month mortality from 17 to 6.3% [3, 4]. It is known that renal dysfunction (estimated glomerular filtration rate (GFR) <30 ml/min/1.73 m²) is present in approximately 30-40% of patients with ACS and is associated with a worse prognosis and increased risk of hospital complications [5, 6].

High-risk ACS necessitates urgent PCI with the use of high doses of radiocontrast agents (RCA) in a very short period of time (2–24 hours), often before obtaining the results of a biochemical examination and making a final diagnosis [7]. Taking into account the fact that the calculation of the amount of contrast agent should be carried out in accordance with the GFR, is an urgent issue of studying the risk factors of contrast-induced nephropathy (CIN) and methods of its prevention in patients with ACS and concomitant chronic kidney disease (CKD) [6, 7]. The most frequent manifestation of CIN is an asymptomatic transient impairment of kidney function, which in a certain percentage of patients can cause irreversible structural changes in the kidneys with the progression of renal failure and is associated with an increase in in-hospital mortality of patients [6, 8]. Patients with severe CKD, acute kidney injury (AKI) and the use of the intra-arterial route of RCA administration are considered vulnerable to the development of contrast-associated nephropathy [9, 10]. In view of current recommendations, important steps in minimizing the risk of CIN are ensuring adequate hydration and limiting the dose of contrast agents, among which low-osmolality agents are preferred [7, 11, 12]. Regarding the effectiveness of prescribing other drugs to prevent CIN, such as N-acetylcysteine, ascorbic acid, statins, febuxostat, etc. the data are either not convincing enough or do not have a sufficient evidence base [13].

The purpose of this work was to identify risk factors for the development of contrast-induced nephropathy in patients with ACS during urgent percutaneous coronary intervention and to investigate methods of its prevention.

MATERIALS AND METHODS OF RESEARCH

The study took place on the basis of the department of interventional cardiology with the resuscitation and intensive care unit and the X-ray surgical unit of the Communal Enterprise "Poltava Regional Clinical Medical Cardiovascular Center of the Poltava Regional Council" within 9 months.

62 patients with ACS (within 24 hours) and concomitant CKD (studied group (SG) were selected for investigation. The study did not include patients with symptoms of acute left ventricular failure (LVEF), left ventricular ejection fraction (EF) less than 30%, known CKD stage IV-V and/or GFR less than 30 ml/min/m². The group included 43 male patients (69.3%) and 19 female patients (30.7%), whose average age was 66.7±1.2 and 74.7±1.8 years, respectively. The percentage distribution of CKD among patients by stages was: I stage – 6.5% (n=4), II stage – 46.8% (n=29), III stage – 46.7%, of which 30.6% (n=19) patients with III A stage and 16.1% (n=10) – III B stage (Fig. 1).

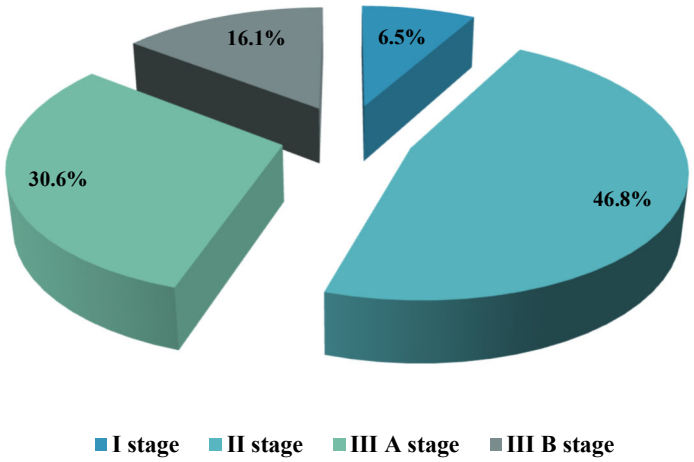

Fig. 1. Percentage distribution of patients with acute coronary syndrome and concomitant chronic kidney disease by stages

Distribution of patients by CKD etiology: diabetic nephropathy (DN) – 56.45% (n=35); hypertensive nephropathy (HN) – 21% (n=13); chronic pyelonephritis (CP) – 19.35% (n=12); gouty nephropathy (GN) – 3.2% (n=2) (Fig. 2).

Patients were divided into 2 groups. The first group consisted of 40 patients who refused to perform in full scope contrast-induced nephropathy prevention algorithm.

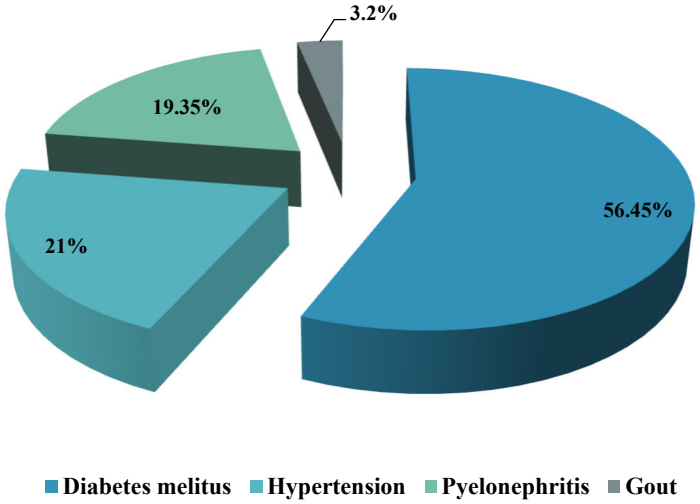

Fig. 2. Percentage distribution of patients by etiology of chronic kidney disease

It included 29 men (72.5%) and 11 women (27.5%), whose average age was 64.3±2.1 and 73.5±1.7 years, respectively. 10% (n=4) of patients were diagnosed with stage I CKD, 45% (n=18) – with stage II CKD, 22.5% (n=9) with stage III A CKD, and in 22.5% of patients (n=9) stage III B CKD was detected; distribution by etiology: 62.5% (n=25) of patients had CKD of diabetic origin, 20% (n=8) had hypertensive nephropathy, 15% of patients (n=6) had pyelonephritis, in 2.5% (n=1) – CKD was associated with gout.

The second group consisted of 22 patients who gave informed consent to the implementation of the preventive treatment algorithm in its entirety. This group included 14 men (63.6%) and 8 women (36.3%), whose average age was 65.1±1.1 and 71.2±1.4 years, respectively. 50% of patients in the second group (n=11) had II stage, 45.5% (n=10) – III A stage and 4.5% (n=1) – III B stage of CKD; distribution by etiology: 45.5% (n=10) of patients had CKD of diabetic origin, 22.7% (n=5) – hypertensive nephropathy, 27.3% of patients (n=6) had pyelonephritis, 4.5% (n=1) – CKD associated with gout. They provided for the use of early statin therapy (Rosuvastatin in a single dose of 40 mg) with subsequent scheduled intake in accordance with existing recommendations and early controlled (by diuresis) combined hydration.

For this purpose, an intravenous infusion of 0.9% sodium chloride solution was performed at the rate of 1 ml/kg/hour from the moment the patient was hospitalized, during urgent PCI and after its completion, which was at least 4 hours on average, followed by combined intravenous and oral hydration by alkaline mineral water with hourly diuresis control. At the time of the study, all patients had no symptoms of acute left ventricular failure and signs of hypoperfusion, BP – 90/60 mm Hg, SpO – 90%, respiratory rate did not exceed 25 per minute, central venous pressure (CVP) did not exceed 15 mm Hg, and did not require inotropic support.

The control group (CG) consisted of 32 patients with ACS without concomitant CKD, of which 20 were men (62.5%) and 12 were women (37.5%), the average age was 65.9±2.1 and 72.8±1.5 years, respectively, which were comparable according to the main indicators.

All patients underwent general clinical examination within two hours after hospitalization. Determination of serum creatinine (sCr) was carried out during the hospitalization, 24, 48 and 72 hours after performing urgent PCI. The sCr level was used to determine the estimated GFR using the CKD-EPI formula and to verify the stage of CKD [7]. The diagnostic criterion for CIN after primary PCI was an asymptomatic increase in sCr within 24-48 hours after urgent PCI using RCA by >25%, compared to the previous value, provided that other, alternative causes of its increase were excluded on the background of a decrease in the level of diuresis ≤0.6 ml/h/kg.

Verification of ACS was carried out by determining the level of troponin I by immunofluorescence analysis on a chemiluminescence analyzer CL-1000 from Mindray using reagents from Mindray. A 12-lead ECG was performed in all patients during hospitalization, immediately after urgent PCI, 1 and 6 hours later. In order to assess the contractility of the myocardium, all patients underwent an echocardiographic examination (EchoCS) in the first 24 hours on a Vivid S60N scanner, according to the

recommendations of the American Society of EchoCS and the European Association of Cardiovascular Imaging Specialists.

The ejection fraction (EF) of the left ventricle (LV) was determined by the method of Simpson discs. The risk of CIN was determined according to the Mehran scale [14].

All patients underwent urgent PCI using a water-soluble, low-osmolarity nephrotropic radiocontrast agent with an average volume of 289±9.9 ml and received basic ACS therapy in accordance with European recommendations (double antiplatelet therapy with loading doses (aspirin 375 mg and ticagrelor 180 mg), low-molecular-weight heparin enoxaparin in therapeutic and prophylactic doses, rosuvastatin, beta-blocker bisoprolol according to th indications) [4], the appointment of angiotensin-converting enzyme inhibitors was carried out taking into account rGFR according to the CKD-EPI formula on the first day.

Mathematical processing of the results was carried out using Statistica 8.0 software (StatSoftInc, USA, license number STA862D175437Q). The average value (M), variance, average standard deviation and median (m), significance level (p) were calculated. The method of logistic regression was used. Processing of the obtained results was carried out using the calculation of the statistical Student's t-test. A difference of $p<0.05$ was considered statistically significant [15].

Written informed consent for the study was obtained from all patients, in accordance with the requirements of the Tokyo Declaration of the World Medical Association, the International Recommendations of the Helsinki Declaration on Human Rights, the Council of Europe Convention on Human Rights and Biomedicine. Our research complies with moral and ethical standards and the main provisions of the Council of European Convention on Human Rights and Biomedicine and relevant legislative documents of Ukraine. The Commission on Ethical Issues and Biomedical Ethics of Poltava State Medical University (protocol No. 215 dated 04.20.23) did not detect any violations of moral and ethical norms during the scientific research work performance.

RESULTS AND DISCUSSION

The distribution of patients with CKD and ACS according to the Mehran scale was as follows: 30.6% (n=19) of patients had a low risk of CIN, 46.8% (n=29) – moderate risk, 19.4% (n=12) – high risk, 3.2% (n=2) – very high risk. At the same time, in CG, 68.75% (n=22) of patients had a low risk, 31.25% (n=10) had a moderate risk of CIN (Fig. 3).

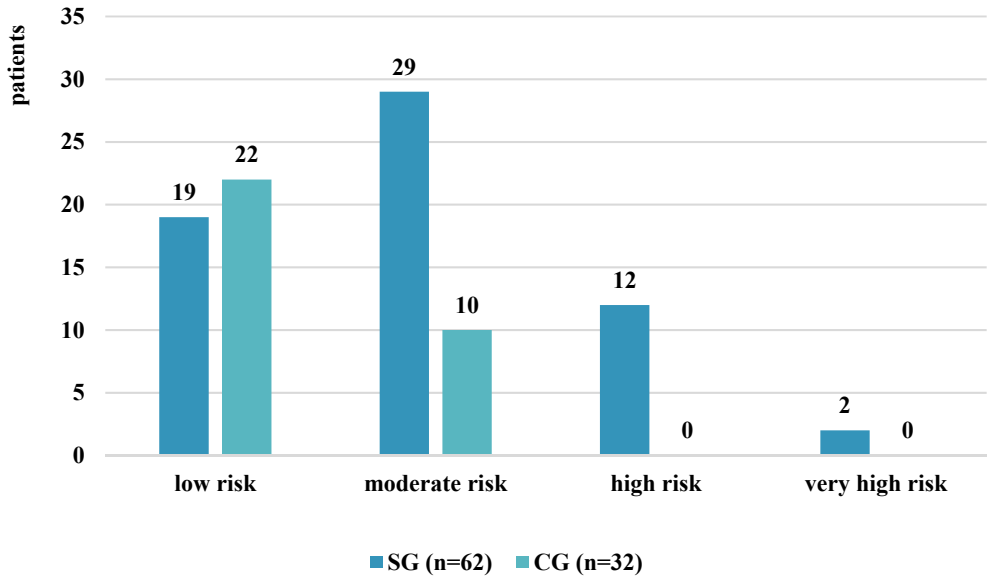

Fig. 3. Distribution of patients in the control group and group with CKD and ACS (SG), according to the risk of developing contrast-induced nephropathy on the Mehran scale

After urgent PCI with the introduction of RCA, CIN was diagnosed in only 21% (n=13) of patients with CKD and ACS based on an increase in the level of sCr, compared to its initial level during the first 24–48 hours after urgent PCI (31.5 to 75.4% (on average 55.1±3.35%)) and a decrease in diuresis in the first 12–24 hours (diuresis was ≤0.6 ml/h/kg). 85% (n=11) of these patients were assigned to the group of high risk of developing CIN, according to the Mehran scale, and 15% (n=2) – to the very high risk group (Fig. 4).

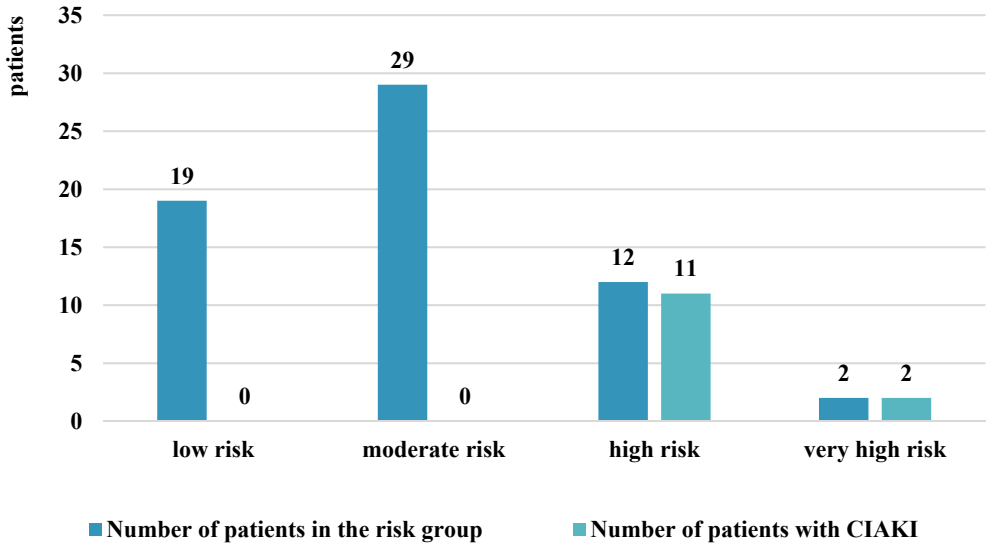

Fig. 4. The number of patients in CKD and ACS (SG) group with contrast-induced acute kidney injury (CIAKI) according to risk groups on the Mehran scale

Among 12 high-risk patients with CKD in combination with ACS, CKD III-A stage was diagnosed in 4 patients and CKD III B stage in 7 patients, which is 91.6%.

In 2 patients of the studied group with CKD III B stage, who were stratified into a very high risk group according to the Mehran scale, CIN developed in both patients, which is 100%. Therefore, if the eGFR is <30 ml/min/1.73 m², the risk of CIN is directly dependent on the stage of CKD. In 49 patients (79%) of studied group with CKD and ACS, there was no significant increase in the level of sCr during the first 24-48 hours after urgent PCI (from 9.9 to 18.7% (on average – 14.3±2.47%)) and changes in diuresis.

In 100% of CG patients (n=32), an increase in the level of sCr during the first 24–48 hours of PCI was from 5.7 to 12.5% (on average – 16.4±0.9%), which is not a diagnostic criterion for CIN.

In addition, changes in the volume of diuresis were also not detected. That is, not a single case of CIN development was recorded in this cohort of patients.

Among patients diagnosed with CIN (n=13), the cause of CKD in 69.2% (n=9) was diabetic nephropathy, in 15.4% of patients (n=2) – hypertensive nephropathy, in 15.4% (n=2) – chronic pyelonephritis (Fig. 5).

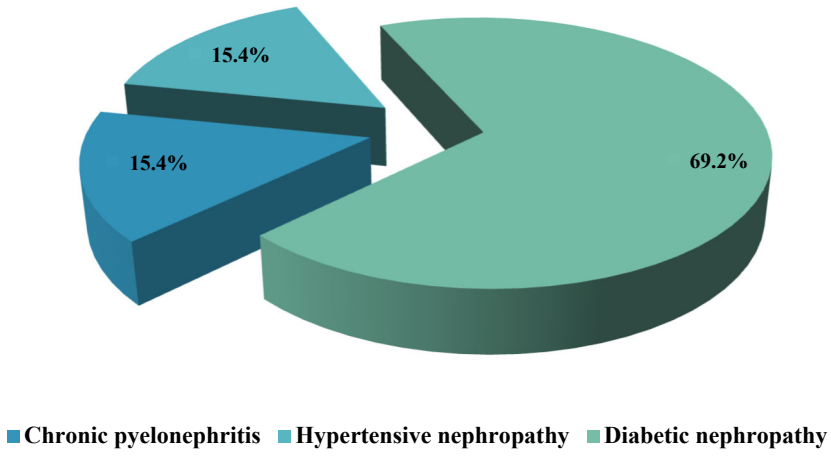

Fig. 5. Percentage distribution of patients in the group with CKD in combination with ACS (SG) and contrast-induced nephropathy, according to the etiology of chronic kidney disease

CIN developed in 9 patients with CKD III-B stage of diabetic genesis who took metformin in a dose of 500–1000 mg in the period from 6 to 12 hours before the introduction of RCA. The mean initial level of GFR in these patients was 37±2.5 ml/min/1.73 m². In the remaining 26 patients with DN contrast-induced nephropathy did not develop.

It should be noted that 10 of them also took metformin in a dose of 500–1000 mg, but their mean initial eGFR was 57±4.1 ml/min/1.73 m². Thus, the combination of eGFR <45 ml/min/1.73 m² and metformin increases the risk of CIN. In the group of patients with diagnosed CIN (n=13), LVEF was from 34 to 40% (on average – 38.2±1.8%), in the group of CKD and ACS without CIN (n=49) – from 43 to 57% (on average – 45.2±1.8%), in CG (n=32) – from 44 to 61% (on average – 44.7±1.5%) (Fig. 6).

In 7 out of 13 patients of the SG (53%) after urgent PCI, a complication of acute myocardial infarction developed – acute left ventricular failure (ALVF).

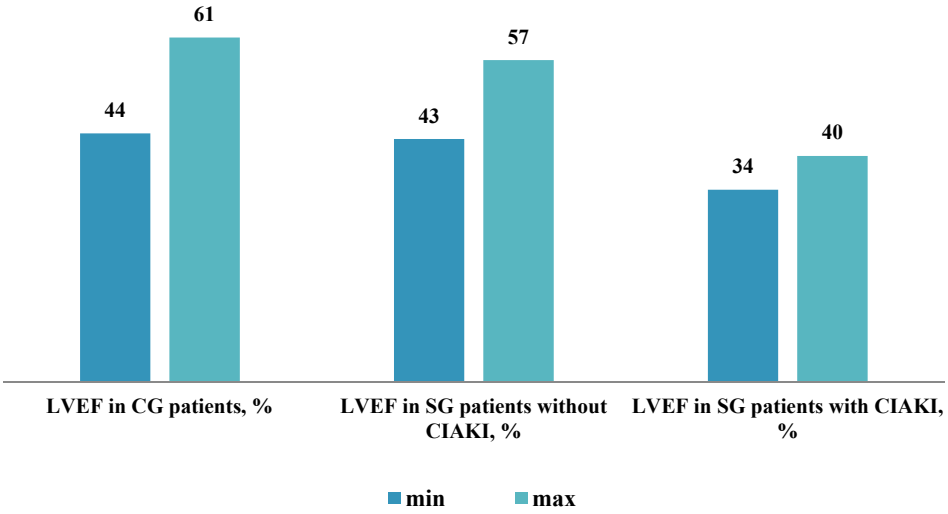

Fig. 6. Range of the left ventricle ejection fraction in of the group with CKD and ACS (SG) and control groups

Killip class III ALVF (pulmonary edema) was detected in 31% (n=4), Killip class IV ALVF (cardiogenic shock) – in 23% (n=3). There were 2 cases of in-hospital death in patients with ALVF of IV class according to Killip and diagnosed CIN, the percentage of mortality was 15.4%. In the remaining 79% (n=49) SG patients without CIN and CG patients, clinically significant signs of ALVF were not observed.

In all 22 patients of the second group, who underwent prevention of CIN, its development was not diagnosed. In 40 patients of group, who refused a full-fledged algorithm of preventive therapy, contrast-induced nephropathy developed in 13 (32.5%) cases. That is, the effectiveness of early statin therapy and controlled (by the level of diuresis) combined hydration in the prevention of CIN in patients with ACS and CKD stages I-III of various etiologies was 100%.

Urgent PCI is the leading method of treatment for patients with acute coronary artery disease.

Despite the benefits, certain categories of patients often develop CIN associated with the use of modern RCA. In order to reduce the risk of CIN, it is recommended to use water-soluble, low-osmolar nephrotropic iodine-containing substances and to adhere to the estimated volume of administration of RCA. But, even if these recommendations are followed, according to a number of studies in high-risk groups (elderly age, diabetes mellitus (DM), CKD, anemia, heart failure), the prevalence of CIN reaches 30%, and the frequency of acute kidney injury (AKI) among patients with DM and symptomatic CKD may reach 50% [6, 9].

According to the results of our study, CIN was diagnosed in 91.6% of patients hospitalized with a diagnosis of ACS, and with a concomitant CKD and, according to the Mehran scale had a high risk of CIN. We observed an increase in sCr by 55.1±3.35% compared to the initial level during the first 24-48 hours after urgent PCI, and a decrease in diuresis in the first 12-24 hours (≤0.6 ml/h/kg), which was considered to be the development of CIN. We also showed that the risk of CIN in patients with ACS is directly dependent on the stage of CKD. A special

cohort of patients consists of patients with type 2 diabetes. CIN in them is one of the significant risk factors of death. The use of a potentially nephrotoxic drug metformin in this category of patients contributes to the development of lactic acidosis, which also increases the risk of contrast-induced acute kidney injury [13]. The data of our study confirm that the combination of reducing GFR to <45 ml/min/1.73 m^2 with metformin significantly increases the risk of CIN. Therefore, the refusal to take this drug 24-48 hours before the introduction of RCA is recommended for patients with severe CKD and chronic coronary disease, or ACS with a low risk of in-hospital and 6-month death.

A number of authors express an opinion regarding the increased risk of CIN in patients with reduced LVEF [11]. Reduction of LVEF below 40% in patients with ACS and CKD was associated with diagnosed CIN. In patients with ACS and CKD without CIN, the LV contractile function was higher (43-57%) than in the previous group. During our study, 53% of patients with ACS and CKD developed ALVF. Among them, pulmonary edema was diagnosed in 31%, and cardiogenic shock in 23%. In patients with ALVF class IV according to Killip and diagnosed CIN, the mortality rate was 15.4%. Thus, a decrease in LV contractile function, a decrease in minute volumetric blood flow, and the development of ALVF in patients with ACS and CKD stages I-III involves prerenal mechanisms in renal perfusion disorders, potentiating the risk of CIN. This gives reason to consider ALVF as one of the most powerful predictors of CIN, the development of which aggravates the course of the underlying disease and worsens its prognosis. New definitions of CIN have appeared in the literature, the authors of which separate "contrast-associated", which may include other causes, and "post-contrast", which indicates only the chronology of events, and not the cause of the development of acute kidney injury. At the same time, AKI induced by RCA is considered an extremely rare phenomenon with an unproven cause-and-effect relationship [10].

Thus, the risk of CIN development is determined by a set of factors, which in our study consisted of: degree of CKD severity (stage of CKD); decreased contractile capacity of the left ventricle; the development of ALVF symptoms and oliguria in the first 12-24 hours after urgent PCI, metformin administration.

In the recommendations on myocardial revascularization for the prevention of CIN, the use of hydration in patients with moderate and severe CKD with the level of evidence I A, as well as short-term courses of statin therapy in high doses, with the level of evidence II A, is proposed [3, 4, 7]. According to other researchers, there is no proven benefit from the use of statin therapy for the prevention of CIN, without additional indications. In our study, in patients with ACS and CKD who were treated with early statin therapy in targeted doses for the prevention of CIN with the aim of treating ACS (renoprotective mechanism cannot be isolated) and controlled (by diuresis level) combined hydration, the development of CIN was not observed in 100% cases, which shows the effectiveness of this technique. It should be noted here that the development of ALVF requires a regimen of water load restriction and does not allow recommending hydration in target doses. Unfortunately, patients with refractory cardiogenic shock have an extremely high risk of developing CIN and often require the use of additional hardware methods of treatment.

CONCLUSIONS

1. The Mehran scale is a universal tool that should be used in routine practice in order to determine the risk of development and timely prevention of contrast-induced nephropathy in patients with acute coronary syndrome and chronic kidney disease during percutaneous coronary intervention.
2. Significant risk factors for the development of contrast-induced nephropathy in patients with acute coronary syndrome and concomitant chronic kidney disease of stages I-III are: a decrease in LVEF (≤40%); the development of acute left ventricular failure of the III and IV classe according to Killip; decrease in the volume of diuresis to ≤0.6 ml/h/kg in the first 12-24 hours after percutaneous coronary intervention; metformin taking 6-12 hours before the administration of the radiocontrast agents with GFR ≤45 ml/min/1.73 m².
3. A prognostically unfavorable clinical scenario for the development of contrast-induced nephropathy during urgent coronary angiography occurs in patients with acute coronary syndrome, complicated by the development of acute left ventricular failure of the III-IV class according to Killip and concomitant chronic kidney disease of stage III B associated with diabetic nephropathy, with the initial level of eGFR ≤45 ml/min/1.73 m² and metformin taking 6-12 hours before the administration of the radiocontrast agent.
4. Prevention of contrast-induced nephropathy with the use of early controlled (by the level of diuresis), combined hydration therapy and early statin therapy in target doses is recommended for patients with acute coronary syndrome and chronic kidney disease.

Contributors:

Miakinkova L.O. – conceptualization, methodology, data curation, writing – review & editing;

Yarmola T.I. – resources, writing – original draft, data curation, writing – review & editing;

Pustovoit G.L. – resources, data curation, verification;

Kostrikova Iu.A. – resources, writing – original draft, visualization;

Pysana B.O. – formal analysis, visualization;

Talash V.V. – writing – review & editing.

Funding. The work was carried out within the framework of the research work "Clinical assessment of the combined effect of cardiovascular risk factors on the comorbid course of arterial hypertension, coronary heart disease and chronic kidney disease, features of prevention and rehabilitation" state registration No 0119U102851 at own expense.

Conflict of interests. The authors declare no conflict of interest.

REFERENCES

1. Chekalina NI. Resveratrol has a positive effect on parameters of central hemodynamics and myocardial ischemia in patients with stable coronary heart disease. Wiad Lek. 2017;70(2,2):286-91.

2. Chekalina NI, Kazakov YM, Mamontova TV, Vesnina LE, Kaidashev IP. Resveratrol more effectively than quercetin reduces endothelium degeneration and level of necrosis factor α in patients with coronary artery disease. Wiad Lek. 2016;69(3,2):475-9.

3. Neumann FJ, Sousa-Uva M, Ahlsson A, Alfonso F, Banning AP, Benedetto U, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. EuroIntervention. 2019;14(14):1435-534.
doi: https://doi.org/10.4244/EIJY19M01_01

4. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et. al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018;39(2):119-77. doi: https://doi.org/10.1093/eurheartj/ehx393

5. Shams E, Mayrovitz HN. Contrast-Induced Nephropathy: A Review of Mechanisms and Risks. Cureus. 2021;13(5):e14842.
doi: https://doi.org/10.7759/cureus.14842

6. Yang Y, George KC, Luo R, Cheng Y, Shang W, Ge S, et al. Contrast-induced acute kidney injury and adverse clinical outcomes risk in acute coronary syndrome patients undergoing percutaneous coronary intervention: a meta-analysis. BMC Nephrol. 2018;19(1):374.
doi: https://doi.org/10.1186/s12882-018-1161-5

7. Ivanov D. [Contrast-induced nephropathy: searching for new solutions to prevent its development]. POCHKI. 2021;8(3):136-8. Ukrainian.
doi: https://doi.org/10.22141/2307-1257.8.3.2019.176450

8. Aksu U, Gulcu O, Aksakal E, Kalkan K, Topcu S. Long-Term Mortality and Contrast-Induced Nephropathy. Angiology. 2019;70(8):783.
doi: https://doi.org/10.1177/0003319718823628

9. Maioli M, Toso A, Gallopin M, Leoncini M, Tedeschi D, Micheletti C, et al. Preprocedural score for risk of contrast-induced nephropathy in elective coronary angiography and intervention. J Cardiovasc Med (Hagerstown). 2010;11(6):444-9.
doi: https://doi.org/10.2459/JCM.0b013e328335227c

10. Macdonald DB, Hurrell C, Costa AF, McInnes MDF, O'Malley ME, Barrett B, et al. Canadian Association of Radiologists Guidance on Contrast Associated Acute Kidney Injury. Can Assoc Radiol J. 2022;73(3):499-514.
doi: https://doi.org/10.1177/08465371221083970

11. Pustovoyt AL, Yarmola TI, Talash VV, Tkachenko LA, Kostrikova UA. [Studying the Main Issues of Contrast-Induced Nephropathy (Review of Literature)]. JMBS. 2018;3(2,11):208-16. Ukrainian.
doi: https://doi.org/10.26693/jmbs03.02.208

12. Van der Molen AJ, Reimer P, Dekkers IA, Bongartz G, Bellin MF, Bertolotto M, et al. Post-contrast acute kidney injury. P. 2: risk stratification, role of hydration and other prophylactic measures, patients taking metformin and chronic dialysis patients: Recommendations for updated ESUR Contrast Medium Safety Committee guidelines. Eur Radiol. 2018;28(7):2856-69.
doi: https://doi.org/10.1007/s00330-017-5247-4

13. Steffens L, Hayes L, Wiebe AZ. Pharmacology of Contrast-In- duced Nephropathy. AACN Advanced Critical Care. 2019;30(2):97-104.
doi: https://doi.org/10.4037/aacnacc2019550

14. Mehran R, Owen R, Chiarito M, Baber U, Sartori S, Cao D, et al. A contemporary simple risk score for prediction of contrast-associated acute kidney injury after percutaneous coronary intervention: derivation and validation from an observational registry. Lancet. 2021;398(10315):1974-83.
doi: https://doi.org/10.1016/S0140-6736(21)02326-6

15. Antomonov MYu. [Mathematical processing and analysis of biomedical data]. Kyiv: Firma maloho druku; 2006. 558 p. Ukrainian.

Стаття надійшла до редакції
19.04.2023