

# Wiadomości Lekarskie Medical Advances



**VOLUME LXXVII, ISSUE 4, APRIL 2024**

Official journal of Polish Medical Association has been published since 1928

ISSN 0043-5147  
E-ISSN 2719-342X



INDEXED IN PUBMED/MEDLINE, SCOPUS, EMBASE, EBSCO, INDEX COPERNICUS,  
POLISH MINISTRY OF EDUCATION AND SCIENCE, POLISH MEDICAL BIBLIOGRAPHY



# Wiadomości Lekarskie Medical Advances



VOLUME LXXVII, ISSUE 4, APRIL 2024

Official journal of Polish Medical Association has been published since 1928

ISSN 0043-5147

E-ISSN 2719-342X



Memory of  
dr Władysław  
Biegański

Wiadomości Lekarskie is abstracted and indexed in: PUBMED/MEDLINE, SCOPUS, EMBASE, INDEX COPERNICUS,  
MINISTRY OF SCIENCE AND HIGHER EDUCATION, POLISH MEDICAL BIBLIOGRAPHY

Copyright: © ALUNA Publishing.

Articles published on-line and available in open access are published under Creative Common Attribution-Non Commercial-No Derivatives 4.0 International (CC BY-NC-ND 4.0) allowing to download articles and share them with others as long as they credit the authors and the publisher, but without permission to change them in any way or use them commercially.

---

**Distribution and Subscriptions:**

Bartosz Guterman    [prenumerata@wydawnictwo-aluna.pl](mailto:prenumerata@wydawnictwo-aluna.pl)

**Graphic design / production:**

Grzegorz Sztank

[fajne.work](http://fajne.work)

**Publisher:**

ALUNA Publishing  
ul. Przesmyckiego 29,  
05-510 Konstancin – Jeziorna  
[www.wydawnictwo-aluna.pl](http://www.wydawnictwo-aluna.pl)  
[www.wiadomoscilekarskie.pl](http://www.wiadomoscilekarskie.pl)  
[www.wiadlek.pl](http://www.wiadlek.pl)



# Wiadomości Lekarskie Medical Advances

**Editor in-Chief:**

Prof. Władysław Pierzchała

**Deputy Editor in-Chief:**

Prof. Aleksander Sieroń

**Statistical Editor:**

Dr Lesia Rudenko

**Managing Editor:**

Agnieszka Rosa – amarosa@wp.pl

**International Editorial Office:**

Nina Radchenko (editor) – n.radchenko@wydawnictwo-aluna.pl

**Polish Medical Association (Polskie Towarzystwo Lekarskie):**

Prof. Waldemar Kostewicz – President PTL

Prof. Jerzy Woy-Wojciechowski – Honorary President PTL

---

**International Editorial Board – in-Chief:**

Marek Rudnicki Chicago, USA

**International Editorial Board – Members:**

Kris Bankiewicz	San Francisco, USA	George Krol	New York, USA
Christopher Bara	Hannover, Germany	Krzysztof Łabuzek	Katowice, Poland
Krzysztof Bielecki	Warsaw, Poland	Jerzy Robert Ładny	Białystok, Poland
Zana Bumbuliene	Vilnius, Lithuania	Henryk Majchrzak	Katowice, Poland
Ryszarda Chazan	Warsaw, Poland	Ewa Małecka-Tendera	Katowice, Poland
Stanislav Czudek	Ostrava, Czech Republic	Stella Nowicki	Memphis, USA
Jacek Dubiel	Cracow, Poland	Alfred Patyk	Göttingen, Germany
Zbigniew Gasior	Katowice, Poland	Palmira Petrova	Yakutsk, Russia
Mowafaq Muhammad Ghareeb	Baghdad, Iraq	Krzyszyna Pierzchała	Katowice, Poland
Andrzej Gładysz	Wrocław, Poland	Waldemar Priebe	Houston, USA
Nataliya Gutorova	Kharkiv, Ukraine	Maria Siemionow	Chicago, USA
Marek Hartleb	Katowice, Poland	Vladyslav Smiiianov	Sumy, Ukraine
Roman Jaeschke	Hamilton, Canada	Tomasz Szczepański	Katowice, Poland
Andrzej Jakubowiak	Chicago, USA	Andrzej Witek	Katowice, Poland
Peter Konturek	Saalfeld, Germany	Zbigniew Wszolek	Jacksonville, USA
Jerzy Korewicki	Warsaw, Poland	Vyacheslav Zhdan	Poltava, Ukraine
Jan Kotarski	Lublin, Poland	Jan Zejda	Katowice, Poland

 CONTENTS

## ORIGINAL ARTICLES

Hlib D. Aleksandrenko, Maryna V. Shevchenko

**Using a chatbot as a digital tool at the primary health care level** 623 

Borys H. Bezrodnyi, Ihor V. Kolosovych, Ihor V. Hanol, Ihor V. Cherepenko, Viktor P. Slobodianyk, Yevhenii O. Nesteruk

**Comparison of the clinical effectiveness of hepaticojejunostomy and self-expanding metal stents for bypassing the bile ducts in patients with unresectable pancreatic head cancer complicated by obstructive jaundice** 629 

Tetiana S. Gruzieva, Andrii I. Korchevnyy, Maksym V. Palii, Karina O. Diachenko, Volodymyr V. Korolenko

**Traceability and control as levers to prevent leakage from legal circulation when legalizing medical cannabis** 635 Tetiana I. Halenova, Nataliia H. Raksha, Tetiana B. Vovk, Vitalii L. Karbovskyy, Svitlana M. Sholomon, Volodymyr S. Melnyk, Olexii M. Savchuk  
**Cytokine profile in multiple sclerosis patients with and without Covid-19** 640 

Oleksandr A. Kaniura, Olga I. Koval, Nataliia V. Bidenko

**Dental treatment of children under general anesthesia during the period of martial law** 646 

Zinah Majid, Bashaer Muhammad Baqir, Dhirmgam Falih Al-Shimerty, Najah Rayish Hadi

**Ghrelin attenuates the inflammatory response induced by experimental endotoxemia in mice** 652 

Yaroslava V. Korost, Anastasiia K. Shkvarok, Valentyna S. Pekhenko, Daria V. Turchak, Magdalena Kędrak, Paweł Jurczak

**Evaluation of cardiovascular complaints in higher education students experiencing elevated level of situational anxiety during the martial law and peacetime** 659 

Lurii L. Kuchyn, Lesya V. Lyamar, Kateryna Yu. Bielka, Khrystyna V. Storozhuk, Tetiana V. Kolomiets

**New training, new attitudes: non-clinical components in Ukrainian medical PhDs training (regarding critical thinking, academic integrity and artificial intelligence use)** 665 

Lurii L. Kuchyn, Natalia V. Stuchynska, Natalia M. Saveliuk, Nina P. Lytvynenko, Olena O. Khaustova, Pavlo V. Mykytenko, Inna I. Kucherenko

**Studying of psycholinguistic features of doctors' professional communication under war conditions** 670 

Valeria M. Lekhan, Elvira V. Borvinko, Vyacheslav V. Zaitsev, Daniel D. Zaslavskiy















**Characteristics of the mental health of employees of healthcare facilities in the conditions of war** 676 

Nataliia M. Orlova, Gavriilo I. Kovtun, Svitlana E. Holovchanska-Pushkar, Valentyna L. Pylypchuk, Inna V. Palamar, Olena V. Tkachenko, Oksana V. Zadorozhniuk

**Non-communicable diseases and their risk factors in Ukraine: analysis of the global burden of disease 2019 study** 682 

Roman Zakordonets, Anatoliy Senchuk, Inna Doskoch, Alina Zabolotna, Valentina Kaliushna

**Levels of anxiety and depression in patients with endometrial hyperplastic processes and extragenital pathology in the perimenopausal period** 690 

- Olena V. Solyyeko, Serhii O. Tsarenko, Olena V. Maznichenko, Mariia O. Chernykh, Hanna O. Palahniuk, Liudmyla M. Sursaieva, Elena V. Maiko  
**Landscape therapy: rehabilitation potential in patients with post-infarction atherosclerosis** 696 
- Olena I. Turos, Arina A. Petrosian, Tetiana P. Maremukha, Varvara V. Morhulova, Dmytro M. Grabovets, Nina V. Brezitska, Tetiana V. Tsarenok  
**Long-term trends (compared to the pre-war period) and public health impact of surface ozone in Ukraine** 703 
- Iryna V. Vasylieva, Serhii L. Shevchenko, Kateryna O. Hololobova, Anna V. Laputko, Serhii V. Kiriienko  
**Spiritual health under the wartime: existential aspects** 710 
- Tatiana A. Vezhnovets, Oleksandr V. Korotkyi, Vitalyi G. Gurianov, Valentin D. Paryi, Tetiana M. Orabina, Andrii O. Pysariev, Yurii V. Marushko  
**Predicting fertility, neonatal and perinatal mortality, and stillbirths for evaluation of the needs for perinatal care in the future post-war reconstruction of Ukraine** 716 
- Oleksandr M. Voloshyn, Yurii V. Marushko, Tetiana V. Hyshchak, Iryna I. Savchenko  
**A comprehensive analysis of anthropometric indicators in preschool children suffering from recurrent respiratory infections** 724 
- Olga K. Didyk, Volodymyr V. Chernyavskyi, Vadym P. Shypulin, Victoriia V. Tishchenko  
**Effectiveness of rifaximin and probiotics for the correction of intestinal permeability in patients with metabolic-associated fatty liver disease in combination with type 2 diabetes mellitus** 732 
- Dmytriy G. Zhaboedov, Rimma L. Skrypnyk, Nataliia A. Tykhonchuk, Alla I. Zadorozhna, Inna D. Skrypnychenko, Svitlana I. Lekhnitska, Ivanna V. Sakhandia  
**Peculiarities of local immunity in dry eye disease on the background of hormonal dysfunction** 739 
- Tetiana M. Kostiuk, Oleksandr M. Hryban, Tamara R. Kostiuk  
**Study of axiography changes in patients with temporo-mandibular joint dysfunction** 744 
- Nataliia I. Zhachko, Iryna L. Skrypnyk, Romana O. Golod, Maksym S. Zhachko, Tamara S. Nespriadko-Monborgne  
**Treatment of patients with crowding of the anterior group of teeth by circumferential supracrestal fiberotomy** 750 
- Tetiana S. Gruzieva, Nataliia V. Hrechyshkina, Hanna V. Inshakova, Ivan M. Soroka  
**Modern educational needs of specialists in the public health system** 758 
- Serhii M. Hryshchuk, Valentin D. Parii  
**Cost-effectiveness of dialysis and kidney transplantation to treat end-stage renal disease in Ukraine** 765 
- Anatolii V. Ivaniuk  
**Morbidity and prevalence of diseases of the circulatory system in the adult population of the Kyiv region, including the working-age population** 772 
- Olena Ya. Antonyuk  
**Patient-centered approach to the management of acute kidney injury in the Covid-19 outcomes** 778 
- Oleg M. Vlasenko, Inna Kucherenko, Maryna Ya. Turchyn, Olha Nechushkina, Viacheslav Kobrzhytskyi, Oksana A. Hrytsenko  
**Values of academic integrity in higher medical education** 784 

Aidyn G. Salmanov, Oleksandr M. Yuzko, Bohdan Yu. Tofan, Volodymyr V. Artyomenko, Svitlana M. Korniyenko, Victor O. Rud, Olena A. Dyndar, Orusia A. Kovalyshyn, Tetiana R. Nykoniuk, Nataliia M. Nastradina

**Factors associated with female infertility in Ukraine: results a multicenter study**

790 

Iryna H. Kupnovytska, Nelia M. Romanyshyn, Iryna P. Fitkovska, Nataliia V. Gubina, Sergej Z. Krasnopolsky, Vira I. Klymenko, Svitlana M. Kalugina

**Effect of ivabradine on structural and functional changes of myocardium and NT-proBNP levels in patients with stable coronary heart disease after coronary stenting**

800 

Anna Dobrovolska

**Professional self-determination of future doctors: priorities in conditions of the war in Ukraine**

811 

Olena V. Solyeyko, Mariia O. Chernykh, Iryna A. Iliuk, Iryna V. Baranova, Iryna B. Romash, Arthur M. Berezovskyi, Larysa P. Soleiko

**Asthma in patients with the syndrome of undifferentiated dysplasia of connective tissue: peculiarities of the course or mutually aggravating mechanisms?**

821 

Maysaa Ali Abdul Khaleq

**Effect of Enoxaparin on D-dimer levels in hospitalized Corona Virus patients with a comparison of its level in patients with comorbid conditions**

828 

## REVIEW ARTICLES

Halyna V. Bilavych, Natalia V. Sultanova, Uliana Z. Borys, Inna M. Tkachivska, Nadiya O. Fedchyshyn, Larysa Ya. Fedoniuk, Borys P. Savchuk

**Health-saving technologies as a need and lifestyle of Ukrainians**

834 

Viktoriiia V. Korolenko, Hennadii A. Mokhort

**Influence of respiratory infections pandemics on the mortality of the population of Ukraine**

841 

Olena S. Skrypnikova, Tetiana P. Yurochko

**Current challenges in accessibility to ophthalmological care in Ukraine**

847 

Solomiia M. Turianytsia, Tetiana P. Yurochko, Kostyantyn V. Balashov, Olesya P. Hulchiy

**Environmental competencies for healthcare management at a 2nd education level as a component of strategic management**

853 

Oleksandr A. Melnychenko, Zhanna M. Ovcharova

**Current challenges in the healthcare sector and respective response measures**

859 

## ABSTRACT BOOK

**SCIENTIFIC AND PRACTICAL CONFERENCE WITH INTERNATIONAL PARTICIPATION DEDICATED TO THE WORLD HEALTH DAY 2024 «MY HEALTH, MY RIGHT»**

863 



# Patient-centered approach to the management of acute kidney injury in the Covid-19 outcomes

Olena Ya. Antonyuk<sup>1,2,3</sup>

<sup>1</sup>BOGOMOLETS NATIONAL MEDICAL UNIVERSITY, KYIV, UKRAINE

<sup>2</sup>NATIONAL MILITARY MEDICAL CLINICAL CENTRE "MAIN MILITARY CLINICAL HOSPITAL", KYIV, UKRAINE

<sup>3</sup>UNIVERSAL CLINIC "OBERIG" KYIV, UKRAINE

## ABSTRACT

**Aim:** To identify patients at risk of AKI with severe COVID-19 and to guide management strategies according to national and global scientific data for improving kidney-related outcomes.

**Materials and Methods:** We conducted retrospective study case-control analysing cases of hospitalisation patients with COVID-19 with or without AKI during hospital stay.

**Results:** In the study, we found that there was a positive correlation between AKI and respiratory insufficiency (0.513 – moderate,  $p < 0.0001$ ), moderate in the case of AKI grade 2 (0.301,  $< 0.001$ ) and mild in the case of AKI grade 1 and 3 correspondingly (0.252,  $p < 0.01$ ; 0.277,  $< 0.001$ ). Lethality (in-hospital death rate) correlated with respiratory insufficiency and AKI (0.733, 0.617;  $p < 0.0001$ ). We found that age had a reverse correlation with AKI and RI (younger patients were more likely to have a higher prevalence of AKI and RI,  $p < 0.001$ ). It was noticed that AKI correlated with the minimal albumin level (-0.35,  $p = 0.016$ ), minimal lymphocyte count (-0.377,  $p < 0.0001$ ), IL-6 (0.201,  $p = 0.035$ ), ferritin (0.34,  $p < 0.0001$ ), maximal CRP (0.439,  $p < 0.0001$ ). There was a mild correlation between Padua Score and AKI (0.232,  $p < 0.01$ ) and PLRI (0.172,  $p = 0.05$ ).

**Conclusions:** Early assessment of renal dysfunction could be used as a marker of severe outcomes of COVID-19, especially in the case of comorbidities such as metabolic disorders and cardiovascular events. We suggest using the Padua score, assessment of personal lethality risk index (PLRI), and rise of serum creatinine as additional tools for assessment criteria for hospitalisation.

**KEY WORDS:** COVID-19, prevention, acute kidney injury, public health, treatment

Wiad Lek. 2024;77(4):778-783. doi: 10.36740/WLek202404125 DOI

## INTRODUCTION

Community-acquired COVID-related acute kidney injury (AKI) is an important research direction. We tried to find approaches to optimise health care, focusing on diagnosing and managing AKI. The interrelationships between respiratory insufficiency, sepsis and AKI should still be discussed. According to the Kidney Disease Improving Global Outcomes (KDIGO) consensus, AKI is defined as a sudden loss of excretory kidney function [1], with the onset of development within seven days. AKI affects about half of patients admitted to the intensive care unit (ICU) and worsens their short- and long-term outcomes [2, 3]. AKI has a high prevalence in patients with COVID-19 hospitalised in the ICU [4]. Combining serum creatinine (SCr) and cystatin C provided good risk prediction in AKI [5, 6].

## AIM

The study aims to identify patients at risk of AKI with severe COVID-19 and to guide management strategies

according to national and global scientific data for improving kidney-related outcomes.

## MATERIALS AND METHODS

The research methods included medical and statistical, content analysis, structural-logical analysis, clinical, laboratory, and instrumental techniques. We conducted retrospective study case-control analysing cases of hospitalisation patients with COVID-19 with or without AKI during hospital stay.

## RESULTS

We conducted retrospective analysis of hospitalisation due to COVID-19 with or without AKI in the group of patients hospitalised to private hospital in Kyiv ( $n = 129$ ) (Table 1). The group was divided into 2 groups: those who had AKI and those who did not have significant changes in kidney function. We performed statistical analysis of data using

**Table 1.** Clinical and laboratory findings in hospitalised COVID- inpatients in the groups (with AKI and without AKI)

	<b>AKI group (n=19) Males 10, females 9</b>	<b>Non-AKI group (n=110) Males 46, females 64</b>	<b>P</b>
Males, %	52,6 (29,2-75,5)	41,8 (32,7-51,2)	p=0,536.
BMI, kg/m <sup>2</sup>	30.6±2.3	28.42±1.2	p=0,473.
Age, years (Me, IQR)	79 (64-80)	81 (78-84)	p<0,001
LYM*10 <sup>9</sup> /l (Me, IQR)	0,2 (0,1-0,39)	0,5 (0,34-0,76) (n=109)	p<0,001.
Maximum grade of respiratory insufficiency, (Me, IQR)	3 (3-3)	1 (1-2)	p<0,001
Duration of hospital stay (Me, IQR)	14 (9-22)	10 (7-13)	p=0,025
% CT (Me, IQR)	61 (40-75) N=14	30 (15-50) N=85	p=0,004.
CRP, mg/l (Me, IQR)	134,26 (93.54-185.06) N=19	44,765 (20.43-93.26) N=110	p<0,001.
HbA1c, % (Me, IQR)	5.5 (5.09-7.07) N=18	5.29 (4.79-5.95) N=106	p=0,111.
Ferritin, mcg/l (Me, IQR)	1094 (686-1176) N=17	375 (187-647.5) N=107	p<0,001.
IL-6 pg/mL, Me (Me, IQR)	48,55 (18-110,65) N=16	25,1 (10,2-46,2) N=97	p=0,029.
Baseline eGFR (on admission), ml/min*1,73 CKD,	60,41±5,61 N=19	60,06±1,96 N=106	p=0,944.
Minimal eGFR, ml/min*1,73 (Me, IQR)	18,4 (10,7-27,4) N=19	58,55 (42,1-74,9) N=94	p<0,001.
Min eGFR, ml/min*1,73 M±m	19,78±2,42 (p<0,001.)	-	p<0,001.
ALT, U/L, Me (QI-QIII)	29.1 (22,9-37,6) N=19	26.9 (16.9-41) N=108	p=0,339.
AST, U/L, Me (QI-QIII)	36.9 (26.8-67.9) N=19	35.4 (25.7-46.65) N=108	p=0,258.
AST/ ALT, Me (QI-QIII)	1,38 (1.11-1.47) N=19	1,31 (1-1.77) N=108	p=0,850.
Baseline Albumin (on admission), g/L, Me (QI-QIII)	32.07 (31.1-36.3)	33.68 (31.53-35.8)	p=0,588.
Albumin (on admission), g/L, M±m	33.37±1.1		
Minimal Albumin, g/L, M±m	27,64±0.9 (p<0,001.)	32.02 (26.37-35.91)	(p<0,001.)
Prevalence of Diabetes Mellitus, % (95% CI)	26,3 (8,6-49,4)	24 (16,1-32,9)	p=0,936.
Prevalence of cough, % (95% CI)	31.6 (12,1-55,2)	49.1 (39.7-58.5)	p=0,240.
Prevalence of Dyspnea, % (95% CI)	47.4 (24,5-70,8)	36.4 (27.6-45.6)	p=0,517.
Prevalence of fever, % (95% CI)	68,4 (44.8-87.9)	76.4 (67,9-83.9)	p=0,661.
Prevalence of frailty, % (95% CI)	94.7 (79.3-100)	96.4 (92-99.1)	p=0,742.
Prevalence of diarrhea, % (95% CI)	10.5 (0,8-29,2)	8,2 (3,8-14,1)	p=0,913.
Lethality (in both groups 31.8 (24-40.1)	100 (90.5-100)	20 (13-28)	p<0,001.
COMORBIDITY*[9]	2 (1-3)	2 (1-3)	p=0,547.
PLRI (personalized lethality risk index)[ 9]	5.1±0.4	4.3±0.2	p=0,048.
Padua Score	4 (3-4)	3 (3-3)	p=0,010.
Increase in SCr, times (95% CI)	2.25 (1.77-4.37)	1 (1-1.04)	p<0,001.
Prevalence of Grade 1 AKI, % (95% CI)	26,3 (8.6-49.4)		
Prevalence of Grade 2 AKI, % (95% CI)	36,8 (16-60,7)		
Prevalence of Grade 3 AKI, % (95% CI)	36,8 (16-60,7)		

**Table 2.** Rank correlation indexes between AKI and respiratory insufficiency (RI) -associated conditions

AKI & RI	0.513		AKI & RI		
			GRADE1	0.252	<0,01
			GRADE2	0.301	<0,001
			GRADE3	0.277	<0,001
RI & Lethality	0.733	<0,0001	AKI & Lethality	0.617	<0,0001
RI & AGE	-0.375	<0,0001	AKI & AGE	-0.304	<0,001
RI & ALB min	-0.532	<0,001	AKI & ALB min	-0.35	0,016
RI & PADUA	0.426	<0,0001	AKI & PADUA	0.232	<0,01
RI & IL-6	0.388	<0,0001	AKI & IL-6	0.201	0,035
RI & CRP max	0.467	<0,0001	AKI & CRP max	0.439	<0,0001
RI & FERR	0.451	<0,0001	AKI & FERR	0.34	<0,0001
RI & LYM	-0.611	<0,0001	AKI & LYM	-0.377	<0,0001
RI & Duration	0.376	<0,0001	AKI & Duration	0.206	0,02
RI & PLRI	0.406	<0,0001	AKI & I PLRI	0.172	0,05

Medstat. When performing the analysis for quantitative indicators, the mean value (M), standard error ( $\pm m$ ) and 95% confidence interval (95% CI) were calculated for the normal distribution, and the median value (Me) and interquartile range (QI–QIII) were calculated for the non-normal distribution. For qualitative indicators, prevalence (%) and 95% confidence interval (95% CI) were calculated. The Mann-Whitney test was used to compare mean values in two groups for quantitative measures, and the chi-square test (with Yates' correction) was used to compare qualitative measures. All calculations were performed for a critical significance level of 0.05.

We used AKI criteria based on KDIGO (Kidney Disease Improving Global Outcomes) criteria in patients with elevated baseline serum creatinine (SCr); stage 1—increase in SCr by 0.3 mg/dl within 48 hours or a 1.5 to 1.9 times increase in SCr from baseline within seven days; stage 2—2.9 times increase in serum creatinine within seven days; stage 3—3 times or more increase in SCr within seven days or the initiation of RRT [1, 8].

In our previous study we proposed using personalized lethality risk index (PLRI) calculation as an indicator summarising the following criteria, such as presence of comorbidities (arithmetic sum of the number of organ systems affected by a chronic pathology according to ICD-10, or COMORB); 2) age over 70 years; 3) presence of obesity (BMI more than 30 kg/m<sup>2</sup>); 4) presence of cardiovascular disease; 5) neurological pathology (cerebrovascular events) in the past; 6) respiratory failure with decreased blood saturation (SpO<sub>2</sub> < 92 %), requiring the oxygen therapy and glucocorticoid administration; 7) pulmonary parenchymal involvement over than 50 %. The presence of one of the above criteria resulted in a score of 1. The personalized lethality risk index was calculated as the sum of these scores [9].

We also calculated rank correlation indexes between AKI and respiratory insufficiency (RI) -associated conditions and presented them in the table 2.

In our study, we found that there was a positive correlation between AKI and respiratory insufficiency (0,513 – moderate,  $p < 0,0001$ ), moderate in the case of AKI grade 2 (0.301,  $< 0,001$ ) and mild in the case of AKI grade 1 and 3 correspondingly (0.252,  $p < 0,01$ ; 0.277,  $< 0,001$ ). Lethality (in-hospital death rate) correlated with respiratory insufficiency and AKI (0.733, 0,617;  $p < 0,0001$ ). We found that age had a reverse correlation with AKI and RI (younger patients were more likely to have a higher prevalence of AKI and RI,  $p < 0,001$ ). It was noticed that AKI correlated with the minimal albumin level (-0,35,  $p = 0,016$ ), minimal lymphocyte count (-0.377,  $p < 0,0001$ ), IL-6 (0.201,  $p = 0,035$ ), ferritin (0.34,  $p < 0,0001$ ), maximal CRP (0.439,  $p < 0,0001$ ). There was a mild correlation between Padua Score and AKI (0,232,  $p < 0,01$ ) and PLRI (0,172,  $p = 0,05$ ).

## DISCUSSION

The pathophysiology of COVID-19-associated AKI could be due to multiple mechanisms such as direct viral kidney injury, immune-induced autoimmune reactions or hyperinflammation, sepsis, non-specific pre-renal mechanism, nephrotoxicity of some medications or mechanical ventilation, hypoxemia [3,7, 9, 10].

The pathophysiology of COVID-19-associated AKI could be related to non-specific mechanisms but also to COVID-induced mechanisms, such as direct injury resulting from viral entry through the receptor angiotensin-converting enzyme 2 (ACE2), which is highly expressed in the kidney, an imbalanced renin-angiotensin-aldosterone system, pro-inflammatory cytokines

elicited by the viral infection and thrombotic events, as well it could be caused by non-specific mechanisms include hemodynamic alterations, right heart failure, high levels of PEEP in patients requiring mechanical ventilation, hypovolemia, administration of nephrotoxic drugs, and nosocomial sepsis [12]. Local inflammation and hyperinflammatory immune response could be considered a key role in AKI, as endothelial injury and microvascular clots are essential in the pathophysiology of AKI. However, the issue of renal tropism remains controversial [12].

AKI could be observed in the structure of multiple organ damage in severe and critically ill COVID-19 patients. As it illustrates the influence of cytokine storm on organ lesions, AKI is also caused by hypoxemia [13]. Hirsch J. S. et al., 2020 reported that among patients who required mechanical ventilation, 89.7% had AKI compared with 21.7% in nonventilated patients [14].

Ng J.H. et al., 2020, reported that among 9,657 patients admitted with COVID-19 to the 13 hospitals in New York in 2020, the AKI incidence rate was 38.4/1,000 patient-days and incidence rates of in-hospital death among patients without AKI, with AKI not requiring dialysis (AKI stages 1-3), and with AKI receiving dialysis (AKI 3D) were 10.8, 31.1, and 37.5/1,000 patient-days, respectively [11].

Menez S. et al., 2023 reported that an increase in soluble tumour necrosis factor receptor 1 (sTNFR1) and sTNFR2 was significantly associated with an increased risk of major adverse kidney events (MAKE) [15]. Noticeably, kidney dysfunction is considered to be quite frequent as mild proteinuria or any other urine abnormalities in urinalysis may be often observed in non-severe cases. Still, as well it could predict AKI that causes urgent dialysis necessity or other renal replacement therapy (RRT) [13]. The cost of hospital stay and duration of treatment increases while AKI happens [14, 16, 17]. Wainstein M. et al. (2023) suggest analysing AKI in the severity of the disease (on the individual level) and in the global context, comparing the international effectiveness of health systems while analysing results from countries with different income levels. The authors divided countries by income level and compared AKI incidence during hospital stays [16]. The critical question is whether prevention of AKI is possible and how it could be prevented. However, the answer could be challenging as the necessity of hospitalisation was considered differently in different countries and varied greatly, depending on the health system and medical facilities.

Understanding the mechanisms of kidney damage and AKI in the setting of critical illness and COVID-19 is important, and it can provide a possibility for improvement in health care [14, 17]. The main methods of RRT

include dialysis and renal transplantation, but globally, it is thought to be challenging due to numerous economic, social, and other factors [18]. Hemodialysis and peritoneal dialysis are equally efficient, and it is essential to raise the awareness of patients and the level of medical staff education and provide equal access to all renal replacement therapy types worldwide [18]. During a pandemic or martial period in Ukraine, while the resources are limited and the massive hospitalization with the necessity of urgent RRT could be observed, acute kidney injury developing on the battlefield, in field hospitals or higher-level hospital settings is characterized by poor outcomes [19]. It was reported that patients with AKI and COVID-19 more often required RRT and less frequently recovered kidney function [20].

Neiryneck N. et al., 2015 concluded that both sTNFR1 and sTNFR2 could help predict the outcome of chronic kidney disease (CKD), including diabetic nephropathy, associated with increased all-cause mortality or an increased risk for cardiovascular events (CVE) in advanced CKD irrespective of the cause of kidney disease [21].

To prevent poor outcomes of COVID-19, we propose analysing clinical and laboratory findings. Suppose the person has chronic non-communicable diseases, such as CVD, arterial hypertension, diabetes, metabolic disorders, psychiatric or neurological pathology, especially with high initial ferritin, C-reactive protein, IL-6 levels or poor dynamics. In that case, it is advisable to hospitalise the person after assessing the individual risks. Further study is necessary to clarify the possibility of personal assessment and risk calculation tools based on evidence-based medicine. However, high mortality could be explained by late admission or rapid organ failure in the case of secondary hemophagocytic lymphohistiocytosis. It is necessary to use pandemic experience in the future. Early renal replacement therapy is essential for the effectiveness of AKI grade 3 management to prevent severe complications and in-hospital deaths.

## CONCLUSIONS

It was noticed that AKI correlated with the minimal albumin level ( $-0.35$ ,  $p=0.016$ ), minimal lymphocyte count ( $-0.377$ ,  $p<0.0001$ ), IL-6 ( $0.201$ ,  $p=0.035$ ), ferritine ( $0.34$ ,  $p<0.0001$ ), maximal CRP ( $0.439$ ,  $p<0.0001$ ). There was a mild correlation between Padua Score and AKI ( $0.232$ ,  $p<0.01$ ) and PLRI ( $0.172$ ,  $p=0.05$ ). Early assessment of renal dysfunction could be used as a marker of severe outcomes of COVID-19, especially in the case of comorbidities such as metabolic disorders and cardiovascular events. We suggest using the Padua score, assessment of PLRI, and rise of serum creatinine as additional tools for assessment criteria for hospitalisation.

## REFERENCES

1. Kellum J, Lameire N, Aspelin P et al. Kidney disease: Improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. *Kidney International Supplements*. 2012;2(1):1–138. doi:10.1038/kisup.2012.1. [DOI](#)
2. Jensen S, Heide-Jørgensen U, Gammelager H et al. Acute kidney injury duration and 20-year risks of chronic kidney disease and cardiovascular disease. *Kidney International Reports*. 2024;9:817–829. doi: 10.1016/j.ekir.2024.01.034. [DOI](#)
3. Gabarre P, Dumas G, Dupont T et al. Acute kidney injury in critically ill patients with COVID-19. *Intensive Care Med*. 2020;46(7):1339–1348. doi:10.1007/s00134-020-06153-9. [DOI](#)
4. Scope of Work KDIGO Clinical Practice Guideline for Acute Kidney Injury (AKI) and Acute Kidney Disease (AKD). 2023. [https://kdigo.org/wp-content/uploads/2016/10/KDIGO-AKI-AKD-Guideline\\_Scope-of-Work\\_2023\\_Final.pdf](https://kdigo.org/wp-content/uploads/2016/10/KDIGO-AKI-AKD-Guideline_Scope-of-Work_2023_Final.pdf) [Accessed 15 March 2024].
5. Diebold M, Schaub S, Landmann E et al. Acute kidney injury in patients with COVID-19: a retrospective cohort study from Switzerland. *Swiss Med Wkly*. 2021;151:w20482. doi:10.4414/smw.2021.20482. [DOI](#)
6. Zhang WF, Zhang T, Ding D et al. Use of Both Serum Cystatin C and Creatinine as Diagnostic Criteria for Contrast-Induced Acute Kidney Injury and Its Clinical Implications. *J Am Heart Assoc*. 2017;6(1):e004747. doi:10.1161/JAHA.116.004747. [DOI](#)
7. Lameire N. Reflections on the KDIGO Definition of Acute Kidney Injury and Its Integration in the Concept of Acute Diseases and Disorders and Chronic Kidney Diseases. *Kidney and Dialysis*. 2022;2(1):68–79. doi:10.3390/kidneydial2010008. [DOI](#)
8. Machado MN, Nakazone MA, Maia LN. Acute kidney injury based on KDIGO (Kidney Disease Improving Global Outcomes) criteria in patients with elevated baseline serum creatinine undergoing cardiac surgery. *Rev Bras Cir Cardiovasc*. 2014;29(3):299–307. doi:10.5935/1678-9741.20140049. [DOI](#)
9. Gruzjeva T, Antonyuk O. Analysis of risk factors for severe COVID-19. *KIDNEYS*. 2021;12(1):39–45. doi:10.22141/2307-1257.12.1.2023.393. [DOI](#)
10. Langenberg C, Wan L, Egi M et al. Renal blood flow and function during recovery from experimental septic acute kidney injury. *Intensive Care Med*. 2007;33(9):1614–1618. doi:10.1007/s00134-007-0734-8. [DOI](#)
11. Ng JH, Hirsch JS, Hazzan A et al. Outcomes Among Patients Hospitalized With COVID-19 and Acute Kidney Injury. *Am J Kidney Dis*. 2021;77(2):204–215. doi:10.1053/j.ajkd.2020.09.002. [DOI](#)
12. Legrand M, Bell S, Forni L et al. Pathophysiology of COVID-19-associated acute kidney injury. *Nat Rev Nephrol*. 2021;17(11):751–764. doi:10.1038/s41581-021-00452-0. [DOI](#)
13. Ronco C, Reis T, Husain-Syed F. Management of acute kidney injury in patients with COVID-19. *Lancet Respir Med*. 2020;8(7):738–742. doi:10.1016/S2213-2600(20)30229-0. [DOI](#)
14. Hirsch JS, Ng JH, Ross DW et al. Acute kidney injury in patients hospitalized with COVID-19. *Kidney Int*. 2020;98(1):209–218. doi:10.1016/j.kint.2020.05.006. [DOI](#)
15. Menez S, Coca SG, Moledina DG et al. Evaluation of Plasma Biomarkers to Predict Major Adverse Kidney Events in Hospitalized Patients With COVID-19. *Am J Kidney Dis*. 2023;82(3):322–332.e1. doi:10.1053/j.ajkd.2023.03.010. [DOI](#)
16. Wainstein M, Spyrison N, Dai D et al. Association of Country Income Level With the Characteristics and Outcomes of Critically Ill Patients Hospitalized With Acute Kidney Injury and COVID-19. *Kidney Int Rep*. 2023;8:1514–1530. doi:10.1016/j.ekir.2023.05.015. [DOI](#)
17. Silver SA, Long J, Zheng Y, Chertow GM. Cost of Acute Kidney Injury in Hospitalized Patients. *J Hosp Med*. 2017;12(2):70–76. doi:10.12788/jhm.2683. [DOI](#)
18. Ivanov D. Renal replacement therapy: does the patient have a choice. *KIDNEYS*. 2023;11(4):186–191. doi:10.22141/2307-1257.11.4.2022.383. [DOI](#)
19. Sever MS, Vanholder R, Luyckx V et al. Armed conflicts and kidney patients: a consensus statement from the Renal Disaster Relief Task Force of the ERA. *Nephrol Dial Transplant*. 2023;38(1):56–65. doi:10.1093/ndt/gfac247. [DOI](#)
20. Fisher M, Neugarten J, Bellin E et al. AKI in Hospitalized Patients with and without COVID-19: A Comparison Study. *J Am Soc Nephrol*. 2020;31(9):2145–2157. doi:10.1681/ASN.2020040509. [DOI](#)
21. Neiryck N, Glorieux G, Schepers E et al. Soluble tumor necrosis factor receptor 1 and 2 predict outcomes in advanced chronic kidney disease: a prospective cohort study. *PLoS One*. 2015;10(3):e0122073. doi:10.1371/journal.pone.0122073. [DOI](#)

*The article was performed in framework of research “Medical and social substantiation of the optimization of the healthcare organization in the context of the public healthcare system development” (2020–2022, number of state registration 0120U100807).*

## CONFLICT OF INTEREST

The Author declare no conflict of interest

**CORRESPONDING AUTHOR**

**Olena Ya. Antonyuk**

Bogomolets National Medical University  
34 Prospect Beresteiskyi, 03680 Kyiv, Ukraine  
e-mail: lena.nmu@gmail.com

**ORCID AND CONTRIBUTIONSHIP**

Olena Ya. Antonyuk: 0000-0002-3411-196X [A](#) [B](#) [C](#) [D](#) [E](#) [F](#)

---

[A](#) – Work concept and design, [B](#) – Data collection and analysis, [C](#) – Responsibility for statistical analysis, [D](#) – Writing the article, [E](#) – Critical review, [F](#) – Final approval of the article

**RECEIVED:** 01.12.2023

**ACCEPTED:** 29.03.2024

