ISSN 1562-2940
eISSN 2790-1203

ASTANA MEDICAL UNIVERSITY

ASTANA MEDICAL JOURNAL

Volume 125, Number 5 (2025)

ISSN: 2790-1203 online
ISSN: 1562-2940 print
№125 (5) 2025

2025 жылғы 30 сәуірінде жариялануға қол қойылған.
Журналдың меншік иесі – «Астана медицина университеті» КеАҚ.
Басылым Қазақстан Республикасы Мәдениет және ақпарат министрлігінде тіркелген.
Қайта тіркеуге тіркеу туралы куәлік 2012 жылғы 29 қазандағы No 13129 Ж.

Подписано к печати 30 апреля 2025 года.
Собственником журнала является НАО "Медицинский университет Астана".
Издание зарегистрировано в Министерстве культуры и информации Республики Казахстан.
Свидетельство о постановке на переучет №13129 Ж от 29.10.2012 год.

Signed for publication on April 30, 2025.
The owner of the journal is JSC "Astana Medical University".
The publication is registered with the Ministry of Culture and Information of the Republic of Kazakhstan.
Certificate of registration for re-registration No. 13129 Zh dated October 29, 2012.

Редакцияның мекен-жайы:
Астана медициналық журналы
Z10K8Y7
Қазақстан, Астана қ.
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Тел.: +7 (7172) 53 94 47
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Editorial Office:
Astana medicinalyk zhurnaly
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E-mail: amj@amu.kz
Website: www.medical-journal.kz

NCJSC «Astana Medical University»

Astana Medical Journal

Scientific & Practical journal

Astana, 2025

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj001

Morphological Characteristics of Cervical Intraepithelial Neoplasia in the Context of Human Papillomavirus Infection-Associated Pathology

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Received: 20.04.2025
Accepted: 25.06.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj001.

Abstract

Objective. To systematize the morphological characteristics of cervical intraepithelial neoplasia (CIN) in the context of human papillomavirus infection (HPV)-associated pathology through a literature review and analysis of clinical and morphological data.

Materials and Methods. The study included 40 cervical biopsy specimens obtained from patients with precancerous cervical conditions examined at the Department of Pathological Anatomy, University Medical Center. Histological evaluation was

performed using hematoxylin–eosin staining. Clinical and laboratory data were integrated, including Pap smear results, HPV genotyping, and screening for sexually transmitted infections (STIs).

Results. HPV type 16 was the most frequently detected genotype (14 cases). Coinfections with two HPV genotypes were observed in 9 patients (e.g., 16 and 45, 18 and 51), while 3 patients had triple infections. Sixteen cases were HPV-negative. High-grade CIN (CIN 2, CIN 3, or carcinoma in situ) was diagnosed in 19 of 40 patients (47.5%), even though cytology revealed only low-grade lesions (LSIL) or atypical squamous cells of undetermined significance (ASC-US). Additionally, 4 cases (10%) with NILM (negative for intraepithelial lesion or malignancy) on cytology demonstrated CIN I–II on histology. STIs were identified in 26 patients (65%), predominantly Gardnerella vaginalis (55%), followed by Cytomegalovirus (17.5%), Candida albicans (10%), and Mycoplasma hominis (7.5%), including mixed infections. These findings indicate a high prevalence of HPV and concurrent STIs among patients with CIN, as well as notable discrepancies between cytological and histological diagnoses, particularly in the presence of inflammatory processes.

Conclusions. The study underscores the limitations of cytological screening and the importance of comprehensive diagnostic strategies combining morphological, clinical, and molecular methods. Standardization of morphological criteria for CIN is essential, particularly in HPV-associated and inflammation-related contexts, to improve diagnostic accuracy and patient management.

Keywords: cervical intraepithelial neoplasia, HPV, cytology-histology correlation, sexually transmitted infections, morphology.

1. Introduction

Cervical cancer (CC) is the fourth most frequently diagnosed cancer and the fourth leading cause of mortality in women [1]. According to WHO estimates, in 2022 more than 660,000 new cases and approximately 350,000 deaths were registered globally, with over 90% of deaths occurring in low- and middle-income countries [2]. The incidence is mainly concentrated among women aged 25–59 years, with a peak risk between 45 and 49 years [1]. In Europe, approximately 66,000 new cases of cervical cancer and more than 30,000 deaths are recorded each year, according to the European Cancer Registry [3]. In Kazakhstan, CC incidence remains stable at approximately 19 per 100,000 women, while mortality rates have declined from 7.15 to 5.93 per 100,000, with significant disparities in screening participation between urban (74%) and rural (38%) populations [4].

Cervical intraepithelial neoplasia (CIN) develops through infection by high-risk human papillomavirus (HPV) types, predominantly HPV 16 and 18, which penetrate the basal epithelial layer and establish persistent infection [5,6]. Viral genome integration disrupts oncogene expression, particularly E6 and E7 proteins. E6 induces p53 degradation, reducing apoptosis and DNA repair capacity, while E7 inactivates retinoblastoma protein (pRb), disrupting cell cycle control [7,8]. Viral integration often disrupts the E2 gene, which normally suppresses E6 and E7 expression, enhancing oncogenic effect [9]. These changes lead to genetic abnormalities, chromosomal instability, and

mutations, reflected in the pathomorphological spectrum from mild dysplasia (CIN I) to severe dysplasia (CIN III), characterized by disorganized epithelial stratification, nuclear atypia, and increased mitotic activity [10–12].

In 2020, the WHO published a new classification introducing a two-tier system: low-grade squamous intraepithelial lesions (LSIL/CIN I) and high-grade squamous intraepithelial lesions (HSIL), encompassing CIN II and CIN III [13]. However, the three-tier CIN classification remains widely used in practice. LSIL (CIN I) is characterized by abnormal changes limited to the lower third of epithelium with atypical proliferation, mitoses confined to basal layers, koilocytotic atypia, and preserved cytoplasmic maturation. HSIL (CIN II) demonstrates basal/parabasal morphology with mitotic activity extending to the lower two-thirds, while HSIL (CIN III) displays atypia throughout full epithelial thickness with immature cells and lack of superficial differentiation [14,15].

According to WHO, 99% of HSIL and invasive cervical cancer are caused by HPV and can be detected early with organized screening programs [1]. Recommended detection methods include HPV testing, cervical cytology, and colposcopy; however, microscopic histopathological assessment remains the diagnostic gold standard [14]. Despite modern screening protocols, CIN diagnosis relies heavily on morphological interpretation. A comprehensive approach combining histological verification with virological and cytological data provides more accurate patient risk stratification and helps to avoid both under- and overtreatment.

However, interpretation presents challenges due to inter-observer variability, especially in borderline cases such as CIN I/II or CIN I/III [16]. Background inflammatory changes may mimic or obscure dysplastic processes, complicating differential diagnosis. Moreover, cytological screening frequently underestimates lesion severity compared to histology, leading to delayed diagnosis and treatment. Given the high prevalence of HPV infection among women of reproductive age, particularly in developing countries where vaccination rates are low and screening irregular, early detection of precancerous lesions remains a pressing global health issue. These challenges underscore the critical importance of standardizing CIN diagnostics and integrating morphological and molecular approaches into healthcare systems [17].

Aim of the Study - to identify and analyze discrepancies between morphological, cytological, and PCR data in the diagnosis of HPV-associated cervical pathology, based on 40 clinical cases examined at the Department of Pathological Anatomy, «University Medical Center» (Astana, Kazakhstan).

2. Materials and methods

This study represents a prospective analysis of pathomorphological and clinical–laboratory characteristics of 40 patients diagnosed with CIN between February and June 2025. The study included women aged 18–45 years referred to the "Center for the Prevention and Treatment of Precancerous Cervical Diseases," established at CF "UMC" as part of a state-targeted funding program of the Ministry of Science and Education of the Republic of Kazakhstan. Patients were selected following HPV testing and Pap smear examination. Histopathological studies were conducted at the Department of Pathological Anatomy, CF "UMC," Astana (Kazakhstan), between February and June 2025. Histological materials were obtained from 40 women aged 18–45 years who underwent morphological verification of cervical intraepithelial neoplasia.

The objects of study were cervical biopsy specimens collected during diagnostic evaluation. Lesions were classified in accordance with the most recent WHO recommendations [13]. Based on morphological analysis, cases were distributed as follows: CIN I – 11 cases, CIN II – 18 cases, CIN III – 9 cases (including 4 cases of carcinoma in situ).

Histological processing was carried out using a standard protocol: fixation in 10% neutral formalin, passage through graded alcohols, paraffin embedding, sectioning at 3–5 μm thickness with a microtome, followed by hematoxylin–eosin (H&E) staining. Morphological evaluation was performed under a light microscope at magnifications ×100, ×200, and ×400, with analysis of epithelial architecture, degree of nuclear atypia, mitotic activity, and architectural abnormalities. All cases were classified according to the accepted CIN grading system (CIN I–III, CIS).

Microscopic diagnosis of koilocytosis in histological specimens is considered insufficiently reliable due to subjective interpretation and possible morphological overlap with other epithelial alterations. Therefore, in this study, assessment of HPV-related changes relied primarily on cytological analysis.

This study was approved by the Local Bioethics Committee of the UMC Corporate Foundation (protocol #2024/02-013, 10/05/2024), and all patients provided informed consent for the use of their medical data in research. Morphological findings were correlated with clinical data, and when available, with cytological results and HPV status.

3. Results and discussion

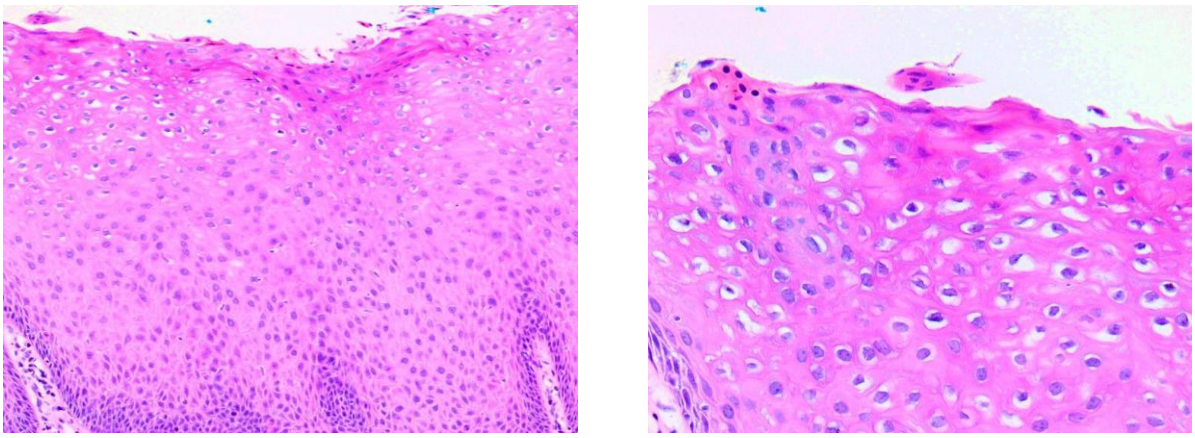
The study included 40 patients with a confirmed diagnosis of CIN. The age of the patients ranged from 20 to 46 years, with a mean age of 31.5 ± 6.3 years and a median of 31 years. Most patients (72.5%) were within the 25–39 age group, corresponding to the peak reproductive period and emphasizing the importance of timely screening in this cohort (Table 1).

Table 1 – Age distribution of patients

Number of cases	Age distribution of patients
0	16-19 years
3	20-24 years
9	25-29 years
10	30-34 years
10	35-39 years

The distribution of CIN grades was as follows: CIN I – 11 cases, CIN II – 18 cases, CIN III – 9 cases (including carcinoma in situ). Two cases were not confirmed histologically and were diagnosed as chronic cervicitis.

Histopathological assessment confirmed the presence of hallmark features of cervical intraepithelial dysplasia in all cases, including nuclear enlargement, hyperchromasia, and increased mitotic activity, with the severity of these changes correlating with CIN grade.



a *b*

Figure 1- Histopathological features of LSIL (CIN I) (a) area of stratified squamous epithelium with features of CIN I: cells with moderate nuclear atypia, preserved differentiation, and koilocytosis in the superficial layers. (b) LSIL showing hyperchromatic nuclei with irregular membranes, variability in cell shape and size, and distinct perinuclear halos in the superficial layers. Staining: Hematoxylin–eosin, magnification: a × 100, b × 400

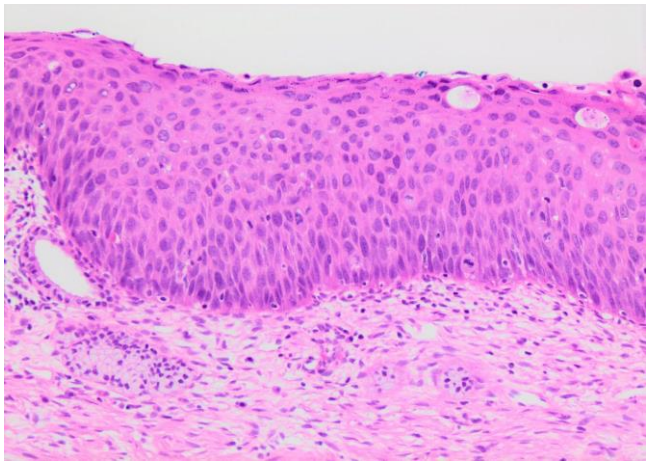


Figure 2— Histopathological features of HSIL (CIN II). Staining: Hematoxylin–eosin, magnification: × 200

At higher magnification, the epithelium demonstrates diffuse nuclear enlargement, with nuclei appearing significantly increased in size. These enlarged nuclei exhibit hyperchromasia, appearing intensely dark-stained, and exhibit irregular nuclear contours with abnormal shapes deviating from normal smooth outlines. Cytoplasmic differentiation is preserved in the upper third of the epithelium. This combination of lower-layer nuclear atypia with retained superficial differentiation is consistent with HSIL/CIN II. Increased mitotic activity is observed in the lower and middle epithelial thirds, showing enhanced cell division in these regions. These features collectively support the diagnosis of HSIL/CIN II.

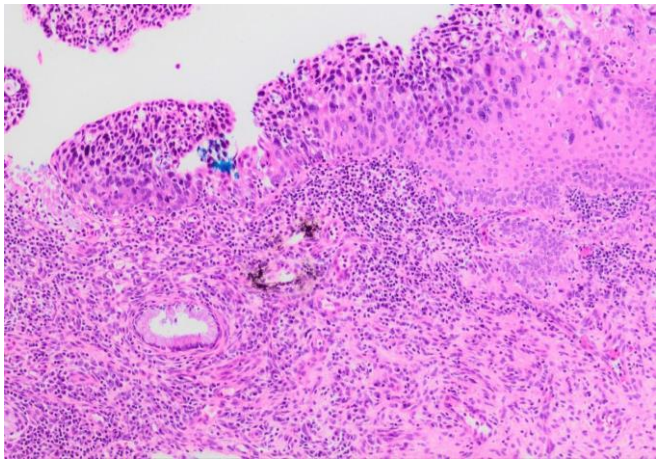


Figure 3 - Histopathological features of HSIL (CIN III). Staining: Hematoxylin–eosin, magnification: × 100

Representative photomicrographs showing histological features of HSIL/CIN III demonstrate focal pronounced nuclear pleomorphism with nuclei showing marked variation in size, shape, and staining intensity. Multinucleated cells are present, displaying multiple enlarged, irregular nuclei within single cell boundaries. These features indicate severe dysplastic changes with loss of normal cellular uniformity. The nuclear pleomorphism and presence of multinucleated cells represent advanced cytopathic effects characteristic of high-grade intraepithelial neoplasia, consistent with CIN III classification.

Table 2 - Histopathological assessment

Patient, №	Histology	Pap smear results	HPV typing	Sexually transmitted infections (STIs)
1	Nabothian cysts of the cervix, chronic cervicitis	ASC-US	39	
2	CIN I, cervicitis	LSIL	16	
3	CIN I, cervicitis	LSIL		Gardnerella vaginalis Cytomegalovirus Candida albicans
4	CIN III, chronic cervicitis	LSIL	16	Gardnerella vaginalis Cytomegalovirus Mycoplasma hominis
5	CIN II	ASC-US		Gardnerella vaginalis Ureaplasma urealyticum
6	CIN II, cervicitis	LSIL		
7	CIN II, cervicitis	LSIL	52	Cytomegalovirus
9	CIN I, cervicitis	NILM		Gardnerella vaginalis
10	CIN II, cervicitis	ASC-US		
11	CIN III	LSIL	16	Gardnerella vaginalis
12	CIN I	LSIL	33	

13	CIN I, cervicitis	ASC-US		Gardnerella vaginalis
14	Squamous cell carcinoma in situ of the cervix with involvement of endocervical crypts. Cervicitis	ASC-H (HSIL)	52,58	Gardnerella vaginalis Cytomegalovirus Candida albicans
16	CIN III	ASC-H (HSIL)	16	
17	CIN II, cervicitis	NILM	31.58	Gardnerella vaginalis
18	CIN I	LSIL	39	Gardnerella vaginalis
19	CIN II, cervicitis	LSIL		Gardnerella vaginalis
20	CIN II, cervicitis	ASC-H (HSIL)	16,45	Gardnerella vaginalis
21	CIN I, cervicitis	ASC-US	52	
22	CIN II, cervicitis, Nabothian cysts of the cervix	LSIL		Gardnerella aginalis Cytomegalovirus
23	Carcinoma in situ of the cervix with foci of microinvasion	ASC-H (HSIL)	16,45,58	Gardnerella vaginalis
24	Glandular ectopy of the cervical columnar epithelium with areas of squamous metaplasia. Dysplasia of the surface epithelium, grade II	ASC-H (HSIL)	16,35	Cytomegalovirus
25	CIN III, carcinoma in situ, cervicitis	ASC-US	16	Gardnerella vaginalis Cytomegalovirus Candida albicans
26	CIN II, cervicitis	ASC-US	16,59	
27	Carcinoma in situ, cervicitis	LSIL	16,18,45	Mycoplasma hominis
28	CIN II	LSIL		
29	CIN III, nabothian cysts of the cervix	ASC-US		Gardnerella vaginalis
30	CIN II	NILM	51	Gardnerella vaginalis Mycoplasma hominis
31	CIN III	LSIL	16	Gardnerella vaginalis
32	CIN II, cervicitis	LSIL	16/45	Chlamedia trachomatis
33	CIN II, cervicitis	NILM		Gardnerella vaginalis
34	CIN I	LSIL	18,51	
35	CIN II, cervicitis	ASC-US		
36	CIN II, cervicitis	LSIL	16,39	Gardnerella vaginalis
37	CIN I	LSIL	16,51	Gardnerella vaginalis
38	CIN I, cervicitis	ASC-H (HSIL)	33,52,58	Gardnerella vaginalis
39	CIN I	LSIL	33,56	Gardnerella vaginalis Candida albicans Ureaplasma urealyticum
40	CIN II	LSIL	59	
41	Chronic cervicitis	ASC-US	-	
42	CIN II	LSIL	33	

** CIN - Cervical Intraepithelial Neoplasia*
ASC-US - Atypical Squamous Cells of Undetermined Significance
LSIL - Low-grade squamous intraepithelial lesion
ASC-H (HSIL) - Atypical Squamous Cells, High-grade Squamous Intraepithelial Lesion
NILM - Negative for Intraepithelial Lesion or Malignancy

In three patients, cytological analysis revealed features of HSIL with prominent koilocytosis (perinuclear halos, nuclear hyperchromasia, and irregular nuclear contours). Morphological verification confirmed CIN II–III, supporting the diagnostic accuracy of cytology in these cases. HPV genotyping demonstrated oncogenic HPV types 16, 35, 45, 52, and 58, confirming high progression risk and underscoring the need for close clinical surveillance and timely intervention (Table 2).

Table 3 - CIN grade distribution and morphological characteristics

CIN grade	Number of patients (n=40)	Percentage (%)	Nuclear enlargement (%)	Hyperchromasia (%)	Mitoses (%)
CIN I	11	27,5%	0	0	0
CIN II	18	45%	4	4	0
CIN III	9	22,5%	9	9	9

** CIN - Cervical Intraepithelial Neoplasia*

Selected clinical cases:

- **Case 1.** A 28-year-old patient presented with a Pap smear result indicating LSIL. HPV genotyping revealed high-risk HPV 16. Histological examination from colposcopy-guided biopsy showed CIN I on the background of cervicitis. No STIs were identified. This case demonstrates concordance between cytology and histology, though the presence of high-risk HPV highlights the need for follow-up.
- **Case 2.** A 31-year-old patient had no cytological abnormalities (NILM). However, HPV genotyping revealed types 31 and 58 (high-risk). Histology confirmed CIN II with chronic cervicitis, and *Gardnerella vaginalis* infection was identified. This case illustrates the limitations of cytology in persistent HPV infection and underscores the importance of combined evaluation including colposcopy and biopsy.
- **Case 3.** A 25-year-old patient presented with LSIL on cytology. HPV testing revealed multiple high-risk types (HPV 16, 18, 45). Histology diagnosed CIN III (carcinoma in situ) with cervicitis. *Mycoplasma hominis* infection was also present. This case emphasizes the discrepancy between cytology and histology, particularly in HPV co-infections, and the need for a more aggressive management approach in high-risk patients (Table 3).

These findings collectively demonstrate the diagnostic value of an integrated approach (cytology, HPV typing, colposcopy, and histology). In some cases, even low-grade or negative cytological results masked significant histological lesions (up to CIN III/carcinoma in situ).

Table 4 - Diagnostic method comparison in selected cases

Patient	PAP smear results	HPV typing	STIs	Histology
№1	LSIL	HPV 16	negative	CIN I, cervicitis
№2	NILM	HPV 31, 58	Gardnerella vaginalis	CIN II, cervicitis
№3	LSIL	HPV 16, 18, 45	Mycoplasma hominis	CIN III carcinoma in situ), cervicitis

** CIN - Cervical Intraepithelial Neoplasia*
LSIL - Low-grade squamous intraepithelial lesion
NILM - Negative for Intraepithelial Lesion or Malignancy
HPV - human papillomavirus

The presented clinical cases were included in the results section to illustrate the diagnostic value of an integrated approach in detecting CIN. These examples demonstrate that Pap smear data alone may be insufficient for an objective assessment of lesion severity. In certain cases, despite low cytological categories (e.g., LSIL or NILM), histological examination revealed more advanced forms of CIN, including carcinoma in situ. This underscores the necessity of combined diagnostics, incorporating cytological, virological, and morphological evaluation for accurate risk stratification and appropriate patient management (Table 4).

The results of this study revealed significant discrepancies between cytological and histological diagnoses in patients with CIN, raising concerns regarding the effectiveness of standard Pap smear–based screening strategies. In 47.5% of patients with cytological diagnoses of LSIL or ASC-US, histological examination confirmed CIN II, CIN III, or carcinoma in situ. Such discrepancies indicate an underestimation of epithelial abnormalities during initial cytological interpretation, which in clinical practice may result in delays in diagnosis and initiation of appropriate treatment.

Moreover, in four patients (10%) with NILM (Negative for Intraepithelial Lesion or Malignancy), histology confirmed CIN I and CIN II. These cases demonstrate the possibility of false-negative cytology results and emphasize the necessity of a combined diagnostic approach that includes HPV testing and colposcopy in addition to cytology.

Similar findings have been reported in large retrospective studies, including one involving 3,798 patients who underwent HPV testing, cytology, and subsequent colposcopic biopsy. According to those data, for CIN I the most common cytological diagnoses were ASC-US (38.2%) and LSIL (36.1%), whereas for CIN II, ASC-US (31.4%) and LSIL (26.6%) also predominated [36]. Thus, moderate lesions may be present even when cytological abnormalities appear minor. For CIN III, HSIL was the most common cytological diagnosis (43.4%), although a substantial proportion of patients presented with milder abnormalities, such as ASC-H (20.6%) and even ASC-US.

Particular attention should be paid to the phenomenon of **undercall**, where CIN II or higher is detected histologically in patients whose cytology results are ≤ ASC-US. In the cited study, 373 such cases were identified. Importantly, HPV 16/18 positivity was more frequently associated with undercall ($p < 0.01$), whereas age over 45 years was associated with a lower risk of diagnostic error [36]. Comparable patterns were observed in our study, where histologically significant lesions were found in some patients despite NILM results.

The discrepancies identified in our research confirm the need to reconsider existing approaches to interpreting screening results and emphasize the importance of integrated diagnostic strategies, particularly in high-risk populations. A combination of Pap smear, HPV genotyping, colposcopy, and, when necessary, directed biopsy should be regarded as the

standard of care for patients with borderline cytological results.

Our findings also align with previously published data that highlight the limitations of cytology as a stand-alone method. Cytology, while effective as a first-line screening tool, cannot always provide sufficient sensitivity or specificity for high-grade lesions, particularly in the context of coexisting infections or inflammatory changes. Conversely, histology allows for more reliable detection of key morphological features associated with progression risk, including nuclear atypia, hyperchromasia, and mitotic activity.

In addition, the detection of high-risk HPV types (16, 35, 45, 52, 58) in conjunction with severe morphological atypia underscores the necessity of incorporating HPV testing into diagnostic algorithms. The combination of HPV typing and histological verification enables more accurate patient stratification, minimizes the likelihood of underdiagnosis, and supports timely therapeutic interventions.

Taken together, these data reinforce the notion that cervical cancer prevention programs must move toward an integrated model that combines cytological, virological, and morphological approaches. Such a strategy not only increases diagnostic accuracy but also improves patient outcomes, particularly in populations with limited access to healthcare resources and high prevalence of HPV infection.

4. Conclusion

The findings of this study underscore the fundamental role of morphological verification in the diagnosis of CIN, particularly in the context of HPV-associated pathology. Despite the advances in virological and cytological screening methods, histological examination remains the most reliable tool for determining the grade of dysplasia and identifying morphological features associated with progression risk, such as nuclear atypia, hyperchromasia, and mitotic activity.

The discrepancies revealed between Pap smear results and histological findings (including cases of CIN III in patients with NILM or LSIL cytology) demonstrate the limitations of isolated cytological diagnostics and emphasize the necessity of a comprehensive diagnostic approach. This approach should include colposcopic monitoring, HPV genotyping, and pathomorphological evaluation.

The presence of high-risk HPV types (16, 35, 45, 52, 58) in combination with pronounced morphological atypia requires special clinical attention, even when cytological findings are of low grade or indeterminate significance.

Thus, the effectiveness of CIN diagnosis and patient management is directly dependent on multidisciplinary collaboration and standardized morphological interpretation. This is particularly relevant in regions with high HPV prevalence and limited oncological screening resources. The results of this study justify the need to strengthen morphological control over precancerous cervical lesions as a key component of invasive cervical cancer prevention.

Conflict of interest: No conflict of interest declared.

Funding: This research was funded by the Scientific Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (grant No. BR24992853, titled "National Program for the Study of HPV with the Development of an Integrated Approach to Effective Diagnosis and Treatment of Precancerous Conditions"). The funding organizations did not participate in the study design, data collection and analysis, decision to publish, or manuscript preparation.

Authors contribution

T.M. Ukybassova, N.K. Kamzayeva, B.A. Ibraimov - Concept and design; N.K. Kamzayeva, M.S. Galym, S.B. Makhambetva, M.S. Galym, D.M. Baktybayeva, K.K. Konrtay, A.G. Toktarkhan, A. Nurgazykyzy - Collection and processing of material; T.M. Ukybassova, N.K. Kamzayeva, B.A. Ibraimov –

Editing; B.A. Ibraimov, M.S. Galym, S.B. Makhambetva, M.S. Galym, D.M. Baktybayeva, K.K. Konrtay, A.G. Toktarkhan, A. Nurgazykyzy - Text writing.

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Адам папилломасы вирусы - ассоцияланған патология контексінде жатыр мойнының интраэпителиалды неоплазиясының морфологиялық сипаттамалары

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Түйіндеме

Зерттеудің мақсаты. Әдебиеттерге шолу және клинико-морфологиялық деректерді талдау негізінде адам папилломасы вирусы (АПВ) - ассоцияланған патология контексінде жатыр мойнының интраэпителиалды неоплазиясының (CIN) морфологиялық сипаттамаларын жүйелеу.

Әдістері. Зерттеуге University Medical Center патологиялық анатомия бөлімінде алдын ала қатерлі ісік аурулары бар пациенттерден алынған жатыр мойнының 40 биопсия үлгісі енгізілді. Гистологиялық бағалау гематоксилин-эозин бояуын қолдану арқылы жүргізілді. Талдауға клиникалық және зертханалық деректер енгізілді, соның ішінде цитологиялық зерттеу нәтижелері (Pap-тест), АПВ типтеу және жыныстық жолмен берілетін инфекцияларға (ЖЖБИ) скрининг.

Нәтижелері. Ең жиі анықталған АПВ түрі 16-тип болды (14 жағдай). Екі реттік АПВ - инфекция 9 пациентте тіркелді (мысалы, 16 және 45, 18 және 51), ал 3 пациентте үштік инфекция анықталды. 16 жағдайда АПВ табылмады. CIN-нің жоғары дәрежесі (CIN 2, CIN 3 немесе carcinoma in situ) 40 пациенттің 19-ында (47,5%) анықталды, цитологияда тек төмен дәрежелі зақымданулар (LSIL) немесе атипия (ASC-US) көрсетілгеніне қарамастан. Бұдан басқа, 4 жағдайда (10%) цитология NILM (интраэпителиалды зақымдану немесе қатерлілік белгілері жоқ) болғанымен, гистологиялық зерттеуде CIN I–II анықталды. ЖЖБИ 26 пациентте (65%) анықталды, көбінесе Gardnerella vaginalis (55%), содан кейін Cytomegalovirus (17,5%), Candida albicans (10%) және Mycoplasma hominis (7,5%), аралас инфекциялармен қоса. Бұл деректер CIN бар пациенттерде АПВ және қосалқы ЖЖБИ кең таралғанын, сондай-ақ қабыну процестері аясында цитологиялық және гистологиялық нәтижелер арасындағы айтарлықтай айырмашылықтарды көрсетеді.

Қорытынды. Зерттеу цитологиялық скринингтің шектеулерін және морфологиялық, клиникалық және молекулалық әдістерді біріктіретін кешенді диагностикалық стратегиялардың қажеттілігін көрсетеді. CIN-нің морфологиялық критерийлерін стандарттау, әсіресе ВПЧ-ассоцияланған және қабыну жағдайларында, диагноздың дәлдігін арттыру және пациенттерді оңтайлы басқару үшін аса маңызды.

Түйін сөздер: жатыр мойнының интраэпителиалды неоплазиясы, адам папилломасы вирусы, цитология мен гистология корреляциясы, жыныстық жолмен берілетін инфекциялар, морфология.

Морфологические характеристики цервикальной интраэпителиальной неоплазии в контексте вирус папилломы человека - ассоциированной патологии

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Абстракт

Цель исследования. Систематизировать морфологические характеристики цервикальной интраэпителиальной неоплазии (CIN) в контексте вирус папилломы человека (ВПЧ) - ассоциированной патологии на основе обзора литературы и анализа клинико-морфологических данных.

Методы. В исследование включено 40 образцов биопсии шейки матки, полученных у пациенток с предраковыми заболеваниями шейки матки, обследованных в отделении патологической анатомии University Medical Center. Гистологическая оценка выполнялась с использованием окраски гематоксилин-эозином. В анализ были интегрированы клинические и лабораторные данные, включая результаты цитологического исследования (Pap-тест), типирование ВПЧ и скрининг на инфекции, передаваемые половым путем (ИППП).

Результаты. Наиболее часто выявлялся ВПЧ 16-го типа (14 случаев). Двойные ВПЧ-инфекции отмечены у 9 пациенток (например, 16 и 45, 18 и 51), у 3 пациенток зарегистрированы тройные инфекции. В 16 случаях ВПЧ не был обнаружен. Высокая степень CIN (CIN 2, CIN 3 или carcinoma in situ) диагностирована у 19 из 40 пациенток (47,5%), несмотря на то, что цитология показала только низкостепенные поражения (LSIL) или атипию неуточненного значения (ASC-US). Кроме того, в 4 случаях (10%) при цитологии NILM (отсутствие признаков интраэпителиального поражения или злокачественности) гистологически выявлен CIN I–II. ИППП диагностированы у 26 пациенток (65%), преимущественно Gardnerella vaginalis (55%), далее Cytomegalovirus (17,5%), Candida albicans (10%) и Mycoplasma hominis (7,5%), включая смешанные инфекции. Эти данные свидетельствуют о высокой распространенности ВПЧ и сопутствующих ИППП у пациенток с CIN, а также о значительных расхождениях между цитологическими и гистологическими результатами, особенно на фоне воспалительных процессов.

Выводы. Исследование подчеркивает ограничения цитологического скрининга и необходимость комплексных диагностических стратегий, объединяющих морфологические, клинические и молекулярные методы. Стандартизация морфологических критериев CIN особенно важна в условиях ВПЧ-ассоциированных и воспалительных состояний для повышения точности диагностики и оптимизации ведения пациенток.

Ключевые слова: цервикальная интраэпителиальная неоплазия, ВПЧ, корреляция цитологии и гистологии, инфекции, передаваемые половым путем, морфология.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj002

Uranium in urine as a bioindicator for detecting uranium accumulation in the human body

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Received: 10.02.2025
Accepted: 26.03.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj002.

Abstract

This review presents data about the potential radiotoxic effects of uranium exposure on the human body and determination of uranium concentration in urine as a bioindicator of uranium accumulation in the human body. The paper discusses the potential applications and methods for determining uranium in urine. The article highlights epidemiological data related to uranium biomonitoring in urine among

uranium workers, military personnel exposed to depleted uranium, and population living in contaminated areas. This article discusses the detected relationships between uranium concentration in urine and health outcomes, including nephrotoxicity. Additionally, the potential of alternative biosubstrates such as hair and nails for assessing chronic uranium exposure in environmental researches discussed. The review also presents our own studies of uranium content in the urine of Group A uranium workers of radiation-hazardous enterprises, for whom biomonitoring is a mandatory component of the annual medical examination, required by national legislation. Over 2,000 urine samples were analyzed using inductively coupled plasma mass spectrometry method. The average uranium concentration was 0.90 μg/l, and peak levels reaching up to 47.15 μg/L. The highest concentrations of uranium in urine were recorded among uranium workers involved in main technological processes. To assess the permissible level of uranium in the human body, the maximum allowable concentration in kidneys was calculated and compared with urinary excretion levels. It was determined that concentrations exceeding 15 μg/l indicate potential nephrotoxicity and necessitate improvements in working conditions for Category A uranium workers. The obtained biomonitoring data not only allow monitoring compliance with permissible dose loads, but also provide the necessary information for optimizing radiation protection measures and making decisions on intervention in cases where exposure levels are exceeded. Recognition of the risks associated with uranium mining and processing in Kazakhstan lead to policy changes aimed at protecting the health of workers and local populations.

Key words: uranium, mass spectrometry, uranium industry workers, uranium ore province, epidemiological studies, health status.

1. Introduction

Uranium is a critical resource for nuclear energy that has brought significant economic and social benefits to humanity. Intensive mining and processing of minerals, as well as nuclear energy complex enterprises' work, have now led, on the one hand, to a sharp increase in the number of people involved in production, and on the other, to the risk of environmental pollution with uranium compounds and its decay products, which poses a potential threat to human health [1-4]. The Republic of Kazakhstan is a unique uranium mining region, which contains about 30% of the world's uranium reserves [5-6]. The country's total uranium reserves are estimated at 802 thousand tons of uranium. In 2009, Kazakhstan took first place in the world in uranium production with an annual increase in this indicator [7].

There are 6 uranium provinces in Kazakhstan, located in the northern, southern, western and central regions of the Republic. The main method of uranium mining is the in-situ leaching method. The country also has uranium processing enterprises [8] and uranium fuel production enterprises. More than 20 thousand people work at uranium mining and processing enterprises in Kazakhstan, of which about 30% are Group A personnel who come into contact with sources of ionizing radiation [9]. In connection with the expansion of production, an increasing number of workers and the population will be involved in the zone of influence of the radiation factor,

so the assessment of the influence of the ionizing factor becomes especially acute.

Uranium and its compounds can enter humans through the respiratory and digestive organs, as well as through the skin, wounds and burn surfaces [10].

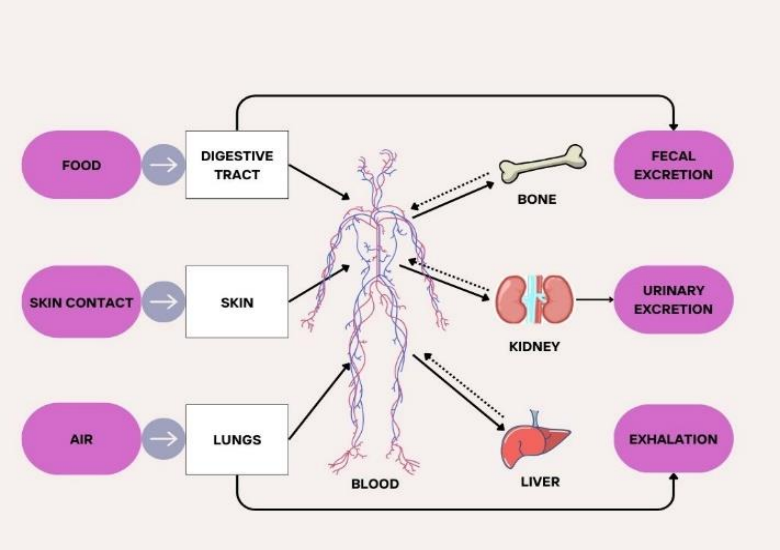

Figure 1 - Receipt, distribution, accumulation and removal of uranium from the human body

For workers involved in uranium industry enterprises, the inhalation route of uranium intake is of greatest importance [4], for the population - oral. The public may be exposed to natural background uranium on a daily basis through food, drinking water and air. However, of great concern is chronic exposure to higher levels of uranium from anthropogenic sources, as well as high dietary uranium intake through contaminated drinking water and food in industrial regions where uranium is mined [11]. Uranium can accumulate in the body, reaching levels in individual organs that may be unsafe for human health [12]. When ingested into the human body in large quantities, uranium can pose a serious danger, and its chemical toxicity exceeds its radiological toxicity. In this regard, regulatory documents provide the permissible value of uranium for chemical toxicity. In terms of its toxic effect, uranium belongs to the 1st hazard class - extremely dangerous chemical substances, and radioactive isotopes of uranium are included in the list of pollutants for which state regulatory measures in the field of environmental protection are applied [13,14]. A special feature of uranium is its dual toxicity due to its radiological effects as an alpha emitter and chemical effects due to its properties as a metal [15]. Assessing the potential adverse health effects of uranium is difficult without biological monitoring, which primarily involves measuring uranium concentrations in urine. Based on the fact that the amount of uranium entering the body can be approximately estimated by the uranium content in urine [16, 17], this article considers this indicator as a potential indicator of uranium concentration in the human body. Relevant studies regarding the content of uranium in the urine of workers and the population of uranium mining regions are described in the following sections of the article, including the own research of the Research Institute of Radiobiology and Radiation Protection of NJSC Astana Medical University.

Aim: to summarize data on the radiotoxicity of uranium and methods for its determination, with an emphasis on the using of mass spectrometry, and to evaluate the effectiveness of urine analysis as a biomonitoring of uranium in the human body of uranium industry workers.

2. Matreials and methods

Methods for determining uranium in the human body

Measuring the concentration of uranium in the human body can be carried out by two main methods: measurements in vivo and in measurements vitro. Methods in vivo measure the amount of uranium deposited within the body using a whole body radioactivity meter. Analyzes in vivo are the most direct method for quantifying radionuclides contained within the body. However, not all radionuclides emit radiation that can be detected with sufficient accuracy; these include 234 U and 238 U due to low-intensity gamma radiation [18]. Methods in vitro allow the assessment of deposited uranium by analyzing biological fluids, excreta, or tissue obtained through biopsy or post-mortem tissue sections [19].

Uranium analyzes in vitro is usually performed on urine samples, but other biomaterials such as blood or feces can also be used. Urine testing for uranium is usually the most preferred test because it is generally more sensitive and less expensive. Stool analysis does not provide information about uranium deposition, and also requires preliminary chemical preparation, and blood analysis is an invasive method [20,21].

Several methods are available for measuring uranium in urine that do not require chemical separation. These methods include spectrophotometric, fluorometric, kinetic phosphorescence analysis and measurement of total alpha activity. However, the listed methods do not allow determining the relative isotopic content of isotopes uranium, which may be important, for example, to distinguish between natural and depleted uranium [22].

Inductively coupled plasma mass spectrometry (ICP-MS), which has better detection limits for many elements, is becoming increasingly widespread as a method for measuring the activity of radionuclides in biosubstrates [23].

Mass spectrometry is a physical method for measuring the ratio of the mass of charged particles (ions) to their charge. Inductively coupled plasma mass spectrometry is based on the use of inductively coupled plasma as the ionization agent [24] and a mass spectrometer for ion separation and detection. The method also allows for isotopic analysis of a selected element; it sorts isotopes depending on their mass-to-charge ratio (m/z), i.e. activity is determined by the number of atoms in the sample, not by radioactivity [25-27].

Mass spectrometry is a more expensive method, but has a number of advantages: high sensitivity, accuracy of detection of uranium isotopes, low detection limit of radionuclides, small amount of material for research and economic benefits due to higher productivity, due to a significant reduction in the time of sample preparation and analysis [28]. In addition, the measurement of various elements, especially toxic metals, by this method is widespread due to the ability to simultaneously measure dozens of elements in a small amount of the test material [25].

It should be noted that methods for determining uranium in urine using inductively coupled plasma mass spectrometry differ and are constantly being improved. Thus, a rapid sample preparation method was developed for the determination of uranium isotopes in samples using a high-resolution ICP-MS sector instrument. This technique can analyze up to 24 urine samples in two hours with low detection limits, which may be useful in a radiation emergency [29].

3. Population outcomes of uranium content in urine

Uranium content in urine of nuclear industry workers

The safety of uranium industry workers requires careful and constant monitoring of their working conditions, therefore the concentration of uranium in urine is most often determined in this category of citizens [thirty]. The guide of the US Nuclear Regulatory Committee "Methods of direct and indirect bioanalysis for workers of uranium mines" shows the maximum permissible value of uranium in the urine of workers of uranium mining enterprises: with monthly analysis - 15 μg/l, with examination once a year - 0.90 μg/l and proposed corrective actions in production depending on the uranium content (Table 1) [31].

Table 1 - Corrective Actions Based on Urine Uranium Test Results [31]

Concentration of uranium in urine	Interpretation	Actions (measures)
less than 15 μg/l	The uranium content in the air sample of the working area complies with regulatory requirements.	Does not require any action. Conduct repeated laboratory tests to determine uranium in urine if the nature of the employee's work changes.
from 15 to 35 μg/l	The uranium content in the work area air sample does not meet the requirements	1. Confirm the result (repeated urine test). 2. Determine the reason for the increase in uranium in the urine and, if the results are confirmed, take additional radiation monitoring measures. 3. Study the results of radiation monitoring to determine the radionuclide composition of air to determine the source and concentration of radionuclide entering the body. If values exceed, examine sampling procedures. 4. Have other workers been exposed to radiation and test their urine for uranium content. 5. Limit work until the concentration of uranium in the urine decreases to 15 μg/l. 6. According to the study, improve control over the intake of uranium through the respiratory tract
more than 35 μg/l	The content of uranium in an air sample is not acceptable	1. Perform the above steps. 2. Continue further action only if another employee's urine concentration of uranium exceeds 35 μg/l. 3. Limit the work of employees, of uranium content in urine when working with uranium dust and yellowcake. 4. Perform weekly laboratory tests for uranium levels in urine.
If the	When workers receive uranium above standard values	1. Take all appropriate measures listed above. 2. Check the urine sample for albuminuria.

concentration is confirmed to be above 35 μg/l for two sequential analyses; upon confirmation, values for any single analysis above 130 μg l or indication of air samples greater than a quarter of the annual limit on intake (that is ¼)		3. If the employee was exposed to a poorly soluble form of uranium or uranium dust, conduct a study of critical organs. 4. Assess the degree of exposure. 5. Establish additional measures to limit the intake of uranium into the body of workers. 6. Consider restriction of work until the concentration decreases to less than 15 μg/L and laboratory tests for albuminuria.

Research at Egypt's uranium processing facilities included external radiation surveillance, monitoring of radioactive dust, and analysis of uranium concentrations in workers' urine. Urine samples collected from plant personnel at the ore crushing and separation site revealed elevated concentrations of uranium (up to 29.2 μg/L) and a strong correlation with serum creatinine levels. The average excretion of uranium in the urine of workers was more than 20 times higher than the permissible level [32]. The daily excretion of U^{238} in urine is 1.4-4.7 times higher than the experimentally established values in the urine of uranium miners and has been shown in other studies [33,34]. Atomic weapons workers are also monitored for possible uranium exposure through urine uranium tests: their average excreted uranium concentration was 0.006 μg/g creatinine. Some urine samples exceeded uranium levels that had been established based on the likely contribution of environmental sources of the radionuclide. However, the health consequences of uranium enriched to <5-8 wt% U235 based on nephrotoxicity in this study were an order of magnitude lower than recommendations given in the literature [35].

Urinary uranium concentrations in individuals associated with military use of depleted anium

Military weapons with depleted uranium have been used by the armed forces of developed countries for 20 years. The use of this type of weapon to solve combat missions in local conflicts (Iraq, 1991, 2003; Bosnia and Herzegovina, 1994; Kosovo and Metohija, 1999; Afghanistan, 2001; Libya, 2011) led to the emergence of a new dangerous factor of technogenic nature. Another object of study where urine tests for uranium content are used are military personnel and the population arriving in areas contaminated with depleted uranium [36-38].

American soldiers who participated in the 1991 Gulf War were injured by fragments containing depleted uranium, or may have been exposed to depleted uranium through other routes, such as inhalation, ingestion, and through wound contamination. Urinary uranium concentrations in soldiers injured by shrapnel were higher than in soldiers exposed to depleted uranium without shrapnel who were not involved in combat [39]. The UK has a biological monitoring program which includes uranium testing of personnel involved in the 2003 Iraq conflict. During The study analyzed urine samples for uranium and creatinine concentrations and for the uranium isotope ratio U^{238}/U^{235}. Uranium concentrations ranged up to 556 ng/g(-1) creatinine, slightly above reference values reported for the US population. Isotope ratio measurements showed that all samples contained a natural isotope and did not contain depleted uranium [40]. There is evidence of uranium

concentrations in urine samples from Afghan civilians. From male civilians who developed symptoms of fatigue, fever, musculoskeletal and neurological changes, headaches and breathing problems after inhaling dust during the 2002 bombings, urine samples were collected and analyzed for the presence of U^{234}, U^{235} and U^{238}. The average uranium concentration (275.04 ng/l) was significantly higher than the reference range (1-20 ng/l). The U^{238}/U^{235}ratio was 137.87 +/- 0.20, which corresponds to the ratio of natural uranium [41]. At the same time the population of eastern Croatia, who live in post-war areas affected by bombing and the potential use of depleted uranium weapons, have urinary uranium concentrations below values reported in the literature [42].

Uranium content in urine of the population

There are a number of studies where uranium in urine was determined in populations not associated with the mining and processing of uranium and who did not participate in military conflicts, including people who live in areas contaminated with radionuclides. The concentration of uranium in the urine of the population is also being studied in order to create a database for comparing the uranium content in the urine of workers engaged in uranium mining and people who live in areas contaminated with radionuclides. There is information on uranium contamination resulting from coal mining activities in the Yi region of China, due to the mixed distribution of uranium and coal mines. This study collected water, soil, coal, and urine samples from the local population to assess the level of uranium intake and its effects on people. The results showed that uranium concentrations in groundwater were 8.71-10.91 μg/L, while lower levels of uranium were observed in river water. Coal ash contained high concentrations of uranium - 33.1 μg/g, due to enrichment during coal combustion. Uranium concentrations in urine samples were 8.44-761.6 ng/L, which is significantly higher than reference values for unexposed people [43]. An assessment of uranium excretion in urine was carried out among the population of the Czech Republic living near spent uranium ore mining and processing facilities. The average daily excretion was 0.15 mBq/day (12.4 ng/day). Despite the legacy of uranium mines and uranium ore processing plants in the Czech Republic, levels of uranium in urine were similar to those in other countries. It should be noted that this study found a significant difference in daily urinary uranium excretion between people using public water supplies and private wells as a source of drinking water [44]. A study was conducted in Japan to examine uranium concentrations in population urine samples to estimate daily uranium excretion. Concentrations ranged from 0.8 to 35.6 ng uranium per liter of urine (mean 4.5 ng/L(-1)). Urinary uranium was normalized to creatinine concentration to compensate for the degree of urine dilution. Normalized creatinine values ranged from 1.2 to 17.8 ng uranium per gram creatinine (mean 7.4 ng/g(-1) creatinine). These results were consistent with the lower limit of uranium uranium reported for the unexposed population of 0.04-0.40 μg/L. It should be noted that the upper limit of this range (0.4 μg/L) was found in an area with high concentrations of natural uranium in water [45].

The urinary concentrations of uranium during chronic exposure to drinking water were studied among households in southern Finland who consume drinking water from private wells. The population was selected to reflect a wide range of daily uranium intakes from drinking water (0.03-2775 μg/day). Urinary uranium was correlated with uranium intake in drinking water, especially at elevated levels of uranium in water (>or =10 μg/day) in wells [46]. A study was carried out to compare urinary uranium levels in the UK population with levels in British military personnel and ex-servicemen serving in areas where ammunition containing depleted uranium was used. Convalescent hospital patients were recruited as participants. The concentration of uranium in daily urine ranged from 1 to 10.6 ng/l(-1). Creatinine - standardized 24-hour urine concentrations ranged from approximately 100 to 800 ng mol (-1) creatinine. The uranium content was similar to that for US residents. All samples showed an isotope ratio of U^{238} to U^{235},

corresponding to natural uranium [47]. Mass spectrometry for determination of Th^{232} and U^{238} in the urine of Jordanians not exposed to uranium showed a mean value of U^{238} in all samples was 3955 μ/Bq/day (-1) (mean 1107 μ/Bq/day (-1)), which is higher than reported data from Germany and India, but consistent with ICRP publication number 23 [48]. The results of determining the activity concentrations of U^{238} and U^{234} in urine samples of Warsaw residents to estimate the background level of the rate of excretion of these radionuclides showed that the excretion rate of U^{238} was in the range of 0.44-30.54 mBq/day (-1), and for U^{234} – in the range of 0.33-28.61 mBq/day (-1). 70% of the results were below the upper limit of 6 mBq/day (-1) recommended by the ICRP for people not exposed to radionuclides (ICRP Publications No23) [49].

Relationship between uranium concentration in urine and human health status

Studies on the concentration of uranium in the urine of uranium industry workers and the population living near uranium deposits in the available world literature. There is even less research regarding urinary uranium and its potential association with morbidity. However, a number of studies have attempted to trace the relationship between uranium concentrations in urine and various diseases. Thus, in the United States, epidemiological studies were conducted that examined the presence of metals in the urine and cognitive impairment in elderly people aged 60 years and older. High levels of urinary cadmium have been found to be potentially associated with impaired memory and mental performance. However, urinary uranium concentrations did not show any significant associations with cognitive impairment [50]. The association of environmental uranium exposure with changes in kidney function in residents of the United States was studied. Uranium was detected in the urine of 74.1% of subjects, and an association was demonstrated between detectable uranium concentrations in urine and microalbuminuria, but no association with clinical kidney disease was identified [51]. The association of urinary metals, including uranium, with the prevalence of diabetes was assessed. The odds ratio for developing diabetes associated with the highest metal concentration was 1.46 (1.09-1.96) for uranium, meaning uranium was positively associated with diabetes, even at relatively low levels observed in the US population [52].

Limitations and disadvantages of testing uranium concentration in urine

The determination of uranium content in urine is carried out to assess its contribution to the dose load of internal irradiation of people, since the rate of excretion of a radionuclide in urine describes the dependence of its content in the body [53]. However, background levels of uranium must be known to assess potential human exposure. Natural background levels of uranium in the urine of unexposed individuals vary greatly depending on region and population, and due to varying intakes of uranium from food and water [54]. There are a number of disadvantages when determining uranium in urine, which can affect the final result. Thus, the amount of uranium in urine samples taken simultaneously (spot) is more variable than in samples taken over 24 hours (daily). Daily urine samples provide greater accuracy in estimating uranium concentrations, but are also more difficult to collect samples [47]. There are studies monitoring occupational exposure to uranium and other toxic heavy metals, including uranium, which show that variations in uranium concentrations in different urine samples from the same person can be quite significant. However, these differences usually correlate with creatinine levels in the same samples. In the studies of Karpas Z., Lorber A. are proposed that daily creatinine levels must be assessed taking into account weight,

height and age; adjusted values can be used to determine the internal radiation dose from uranium [55].

In addition, the list of biomaterials for studying the concentration of uranium in the body is expanding. If we are not talking about uranium poisoning, but are studying the effects of uranium in small quantities, determining the concentration of uranium in hair and nails in population studies is especially relevant. Skin appendages are considered the end product of metabolism that absorbs microelements and their use is effective in environmental and toxicological studies [56]. Hair and nails are composed primarily of fibrous protein structures and grow relatively quickly [57, 58], and the hard outer keratin layer of hair prevents the release of internal components, including external contaminants [59]. In addition, hair and nail samples have several advantages over other types of biomaterials: painless removal, ease of collection and transportation, high stability at room temperature, and relatively high concentrations of elements compared to other body fluids and tissues [60–63].

Despite the above, determining the concentration of uranium in urine remains the most common method for monitoring the effects of uranium on uranium industry workers and the population of uranium mining regions.

Research of uranium content in urine at the Research Institute of Radiobiology and Radiation Protection

The main directions of scientific activity at the Research Institute of Radiobiology and Radiation Protection of NJSC "Astana Medical University" are medical provision of radiation safety and the development of scientific foundations for regulating safe levels of technogenic radiation exposure on workers and the population. The objects of research of the research institute are uranium mining and processing enterprises, whose personnel come into contact with soluble and insoluble uranium compounds [64, 65], as well as the population living near uranium industry facilities [66-68].

According to the order of the acting Minister of Healthcare of the Republic of Kazakhstan No KR DSM-131/2020 dated October 15, it is mandatory to determine the concentration of uranium in urine of uranium mining enterprises (UME) personnel [69]. The main purpose of determining uranium in urine of UME personnel is to ensure radiation safety of workers within permissible dose values, obtain the necessary information to optimize protection, and make decisions on intervention in cases of increased radiation exposure.

Memorandum between the Ministry of Healthcare of the Republic of Kazakhstan and NAC Kazatomprom JSC on cooperation in matters of protecting the health of UME employees to enhancement the interaction between workers and local healthcare organizations was signed in 2018, with the organizational and methodological participation of the SRI of Radiobiology and Radiation Protection, NpJSC “AMU”. From 2015 to 2019, laboratory tests of 2,381 urine samples for uranium content in group A personnel were conducted at the Institute as part of the annual medical examination of UME employees. Laboratory tests of urine samples were carried out on an inductively coupled plasma mass spectrometer “Agilent 7800 ICP MS” (Japan), the error of this device in quantitative determinations is 1-5%.

The main results of measuring uranium in the urine of Kazakhstan UME workers are presented in Table 2.

Table 2 - Uranium content in the urine of group A personnel uranium mining enterprise of Republic of Kazakhstan, μg/l

No	Research objects	Total number of samples	Number of samples with values less than <0.90	Number of samples with values greater than >0.90	Values (μg/l)
1	Uranium mining enterprise of Southern Kazakhstan 1	305	242(79,34%)	63(20,66%)	average 0.74 max 13.68 min 0.029
2	Uranium mining enterprises 1	146	95(65,06%)	51(34,93%)	average 1.74 max 13.68 min 0.08
3	Uranium mining enterprises 2	210	166(79,04%)	44(20,95%)	average 0.59 max 2.91 min 0.001
4	Uranium mining enterprise of Southern Kazakhstan 2	219	166(75,34%)	54(24,65%)	average 1,49 max 33,48 min 0,12
5	Uranium mining enterprise of Southern Kazakhstan 3	213	168(78,87%)	45(21,12%)	average 0,59 max 2,91 min 0,001
6	Uranium mining enterprise of Southern Kazakhstan 4	157	148(94,26%)	9(5,73%)	average 0,58 max 16,97 min 0,10
7	Uranium mining enterprise of Southern Kazakhstan 5	1131	1051(92,92%)	80(7,07%)	average 0,43 max 47,15 min 0,001
Overall average (2 381 samples): 0,90 μg/l					

According to the results of the analysis presented in Table 2, the concentration of uranium in urine varied from 0.001 to 47.15 μg/l, with an average value of 0.90 μg/l. More than 65% of uranium concentrations in urine do not exceed the average meaning of 0.90 μg/l, only 35% and less of rates are above this value.

The presented data shows that in the workshops of the uranium enterprise, in which the main technological processes are carried out, is a significant increase in the average level of uranium concentration in urine compared to other divisions.

Earlier, in the studies of Aumalikova M. and others, studies were conducted to determine uranium in the urine of workers at the Saratov State Chemical Combine, where the concentration of uranium was determined to reach 26.7 μg/l in 4 workers. We reanalyzed urine samples at four workers who has high concentrations of uranium. Three of these workers had 3-5 times decreased uranium concentrations in the urine, while one worker still had urinary uranium concentrations above the maximum threshold (15 μg/L) [8].

To establish the reference value of uranium in the urine of UME personnel, the permissible concentration of uranium in the kidneys was calculated by the empirical formula used in the regulatory documents of the UK, Canada and the USA [70-73]:

$$C = \frac{(5{,}10 \cdot 10^{-34}\,\mu Bq) * (0{,}065)}{(300\text{г}) * (0{,}33 * 10^{-37}\,\mu Bq g^{-1})}$$ = 3,3 10^{-6} g g^{-1} = 3,3 μg/L g^{-1} (1)

where:

C — the permissible concentration of uranium in the kidneys (in g/g),

- 5,10×10^{-34} μBq – activity of uranium,

0,065 – coefficient for conversion in concrete unit of measurement,

- 300 gr – weight of organ (kidneys),

0,33 μBkg x 10^{-37} – a coefficient connecting the activity and concentration of a substance in tissue.

According to the above formula, the maximum uranium content in the kidneys is 3.3 μg/g.

It is necessary to analyze the uranium concentration of urine samples to reduce the impact of high level of uranium, the so-called "peak load" on kidneys. It has been established that this load on the kidneys ranges from 0.3 to 3 μg of uranium per gram of kidney tissue. If the uranium concentration in the renal tissue exceeds 3.3 μg/g (nephrotoxic limit) for a long time, it can lead to kidney damage, and determines the presence of retinol binding protein in the urine [70].

In this regard, the concentration of uranium in the body and the corresponding critical organs (lungs, bones, kidneys) is calculated from analyzes of urine samples taken after a break in work and from the corresponding conversion coefficient from urine activity to uranium content in the body. This method is based on the stabilized distribution of radionuclide in the body of a person working under conditions of chronic intake and achieving an equilibrium state.

According of reference, with a maximum concentration of uranium in the kidney of 3.3 μg/g, the excretion of uranium with urine during its continuous intake into the body after 30 days of exposure, taking into account the half-life of uranium from the body, will be equal to 15 μg/l [70].

Based on previously available data [70-72] and our own research data, to determine the permissible limit of uranium in the urine of UME workers, we constructed a graph compiling the concentration of uranium when yellowcake is ingested at low and high temperatures, as well as uranium ore dust (Figure 2). According to the graph, at the period of uranium exposure increases for UME workers, the concentration of uranium in urine decreases, because slightly soluble forms of uranium can settle in the kidneys, and rapidly soluble forms are excreted from the body in less than 5 days [73, 74].

Thus, the reference value of uranium in the urine of UME workers is 0.90-15 μg/l. If the uranium concentration in the urine of UME workers is exceeded, corrective actions used in world practice and presented in Table 1 are proposed.

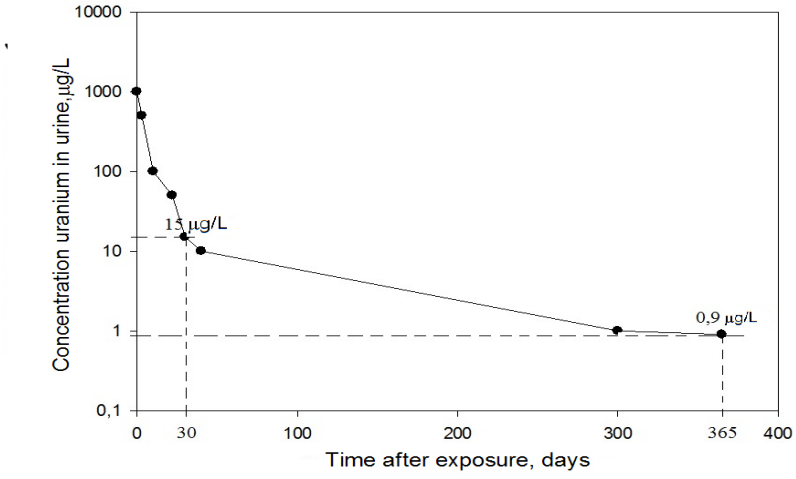

Figure 2 - Uranium concentration in urine versus exposure time

In general, conducting laboratory tests to determine the content of uranium in the urine of UME workers will allow us to identify "risk groups" at an early stage in order to timely predict the risk of developing work-related disorders and occupational diseases, and introduce treatment and preventive complexes aimed at protecting the health of the working population.

With the participation of the Research Institute of Radiobiology and Radiation Protection on the basis of the RSE at the Central Clinical Hospital for Disabled Persons of the Patriotic War and the Institute, the MORBUZ Consortium (Medical Radiation Safety and Morbidity Management) was created, where high-tech specialized clinical examination, treatment and medical rehabilitation of workers are carried out exposed to the negative effects of ionizing radiation.

Research into uranium concentrations in urine in uranium mining regions is ongoing. In the context of the rapidly developing uranium industry in our state, the Institute sets the goal of becoming a center in Kazakhstan for further improvement of comprehensive work to reduce radiation risk for personnel of radiation-hazardous enterprises and near the living population.

4. Conclusion

The use of biological samples to determine uranium levels in the body is important for monitoring the health of people who may be exposed to uranium at work or in the environment. In most cases, urine testing is used to detect uranium exposure through drinking water or inhalation of particles containing uranium. Urine monitoring is an effective method for determining a person's exposure to soluble uranium compounds because the daily urinary excretion of uranium depends on the total level of uranium in the body. The US Nuclear Regulatory Commission (NRC) has set urine uranium levels at 15 μg/L for persons occupationally exposed to uranium. For the population of different regions, the concentration of uranium in urine varies widely, usually in the range of 0.04-0.40 μg/l. Some studies show a relationship between uranium concentration and qualitative changes in the composition of urine, but there is insufficient scientific evidence regarding the existence of a connection between uranium content in urine and the occurrence of somatic diseases. The large body of knowledge obtained from studies of uranium in workers and the public at the Research Institute of Radiobiology and Radiation Protection should be included in the assessment of the health risks associated with uranium exposure. However, this biomonitoring approach has so far found only extremely limited application in the Republic of Kazakhstan; ultimately, we hope that the research conducted will contribute to improving the radiation protection system in our country.

Conflicts of Interest. The authors declare no conflict of interest.

Funding. This research named "Radiation risk of the uranium ore provinces to population health of Northern and Southern Kazakhstan and methods for its reduction" was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP26194983).

Authors' Contributions. YS, MY, KI, MA, DB: Collection and preparation of data, primary processing of the material and their verification, visualization; YS, YK: analysis of the material, writing the text of the article (material and methods, results); YS, MA, DI: Writing the text of the article (introduction, discussion); PK, MB, YK, MH: Concept, design and control of the research, approval of the final version of the article. All authors approved the final version of the manuscript.

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Зәрдегі уран – адам ағзасындағы ураннның жиналуын бағалаудың биоиндикаторы

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Түйіндеме

Бұл шолуда ураннның адам ағзасына әсер етуі нәтижесінде туындауы мүмкін радиоуытты салдарлар және ағзадағы ураннның жиналуын биоиндикациялау құралы ретінде зәрдегі уран концентрациясын анықтау мәселелері қарастырылады. Зерттеу жұмысында зәрдегі ураңды анықтау әдістері мен олардың қолданылу мүмкіндіктері талданады. Мақалада ластанған аумақтарда тұратын халықтың және кедейленген ураннмен байланыста болған әскери қызметкерлер мен жұмысшылардың зәріндегі ураннның биомониторингіне қатысты эпидемиологиялық зерттеулердің деректері көрсетілген. Зәрдегі уран концентрациясы мен денсаулық жағдайы, соның ішінде нефроуыттылық арасындағы анықталған байланыстар сипатталады. Сонымен қатар, ураннның созылмалы әсерін бағалауда шаш пен тырнақ үлгілері сияқты перспективалық альтернативті биосубстраттар да қарастырылады. Шолуда радиациялық-қауіпті кәсіпорындарда жұмыс істейтін А тобының жұмысшыларының зәріндегі уран құрамына қатысты өзіндік зерттеулер нәтижелері ұсынылған. Бұл санаттағы жұмысшылар үшін биомониторинг заңды түрде бекітілген жыл сайынғы медициналық тексерудің міндетті бөлігі болып табылады. Индуктивті байланысқан плазмамен масс-спектрометрия әдісі арқылы 2000-нан астам зәр үлгілері талданды. Орташа уран концентрациясы 0,90 мкг/л құрап, кейбір жағдайларда 47,15 мкг/л-ге дейін жетті. Зәрдегі ураннның ең жоғары мөлшері негізгі технологиялық үдерістерде қызмет атқаратын жұмысшыларда анықталды. Ағзадағы ураннның рұқсат етілген деңгейін бағалау мақсатында бүйректегі шекті концентрация есептеліп, зәрмен

шығарылатын уран деңгейімен салыстырылды. 15 мкг/л-ден жоғары концентрациялар нефроуыттылықтың потенциалдық қаупін көрсетіп, А тобы жұмысшыларының еңбек жағдайларын түзетуді қажет ететіні анықталды. Алынған биомониторинг нәтижелері дозалық жүктемелердің рұқсат етілген деңгейлерін бақылауға ғана емес, сондай-ақ радиациялық қорғаныс шараларын оңтайландыруға және әсер ету деңгейі шектен асқан жағдайда араласу туралы шешім қабылдауға мүмкіндік береді. Қазақстанда уран өндіру және өңдеуге байланысты қауіп-қатерді мойындау – болашақта жұмысшылар мен халықтың денсаулығын қорғауға бағытталған саясатты жетілдіруге жол ашуы тиіс.

Түйін сөздер: уран, масс-спектрометрия, уран өнеркәсібі жұмысшылары, уран-кенді провинциясы, эпидемиологиялық зерттеулер, денсаулық жағдайы.

Уран в моче как биоиндикатор для выявления накопления урана в организме человека

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Резюме

В данном обзоре представлены данные о возможных радиотоксических последствиях воздействия урана организм человека и определения концентрации урана в моче в качестве биоиндикатора накопления урана в организме. В работе рассматривается потенциальное применение и методы определения урана в моче. В статье

освещены данные эпидемиологических исследований, связанных с биомониторингом урана в моче у персонала, военнослужащих, контактирующих с обедненным ураном и у населения, проживающего на загрязненных территориях. В статье обсуждаются выявленные взаимосвязи между концентрацией урана в моче и состоянием здоровья, включая нефротоксичность. Кроме того, затрагиваются альтернативные биосубстраты, такие как волосы и ногти, как перспективные объекты для оценки хронического воздействия урана в условиях экологических исследований. В обзоре приведены и собственные исследования содержания урана в моче у персонала группы А радиационно-опасных предприятий, для которого биомониторинг является обязательной составляющей ежегодного медицинского осмотра, закрепленной на законодательном уровне. Было проанализировано более 2 тысяч образцов мочи методом масс-спектрометрии с индуктивно связанной плазмой. Средняя концентрация урана составила 0,90 мкг/л, при этом в отдельных случаях значения достигали 47,15 мкг/л. Наибольшие значения концентрации урана в моче были зафиксированы у работников, занятых в основных технологических процессах. Для оценки допустимого уровня урана в организме была рассчитана предельная концентрация в почках и сопоставлена с уровнями экскреции урана с мочой. Установлено, что концентрации свыше 15 мкг/л указывают на потенциальную нефротоксичность и необходимость коррекции условий труда персонала группы А. Полученные данные биомониторинга позволяют не только контролировать соблюдение допустимых дозовых нагрузок, но и обеспечивают необходимую информацию для оптимизации мер радиационной защиты и принятия решений о вмешательстве в случаях превышения уровней воздействия. Признание рисков, связанных с добычей и переработкой урана в Казахстане, должно способствовать изменению политики для защиты здоровья работников и населения в будущем.

Ключевые слова: уран, масс-спектрометрия, работники урановой промышленности, урановорудная провинция, эпидемиологические исследования, состояние здоровья.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj003

Frequency of inoculation enterococcus faecalis isolates from various clinical samples from patients with purulent-inflammatory diseases in a non-infectious clinic

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Received: 11.03.2025
Accepted: 18.06.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj003.

Abstract

In recent years, more and more attention around the world has been paid to the problem of antibiotic-resistant strains of bacteria, in particular Enterococcus faecalis, and their role in the development of purulent-inflammatory diseases in humans. This is due to the fact that evidence of a rise in infections caused by antibiotic-resistant strains of E. faecalis is becoming increasingly worrying. In this regard, it is relevant to study the frequency of E. faecalis isolates from patients hospitalized in non-infectious clinics.

Study objective. To investigate the frequency of *Enterococcus faecalis* inoculation from clinical biological samples of patients with purulent-inflammatory diseases over the period from 2018 to 2022 in a non-infectious clinics.

Methods. A retrospective analysis of five-year data from 2018 to 2022 was conducted. The data included results of bacteriological studies to identify pure cultures of *E. faecalis* in the microbiological laboratory of National Scientific Medical Center JSC, Astana.

Statistical processing of the obtained data was performed using Microsoft Excel. The mean value, standard error, and dynamic changes were determined using linear regression. Differences in means were considered statistically significant at $p<0.05$.

Results. From 2018 to 2022, 414 isolates of *Enterococcus faecalis* were identified from various clinical materials. The highest number of strains was obtained from urine (51.9%), followed by wound samples (16.2%), throat (3.6%), and blood (2.2%).

Notably, in 2018, the proportion of strains from urine was 36.8%, while by 2022 it increased to 77.8%.

Conclusions. Based on the analysis of the dynamics of *Enterococcus faecalis* isolates inoculation from various clinical samples from patients with purulent-inflammatory diseases in a non-infectious clinic, the following conclusions can be drawn:

1. During the studied period, the highest level of Enterococcus faecalis inoculation was observed in 2018 (24.9%), and the lowest level of inoculation was observed in 2022 (15.2%).

2. The frequency of *Enterococcus faecalis* inoculation during the studied period, depending on the patient's biomaterial, varied as follows: it was isolated from urine in 215 cases (51.9%), from the wound - 67 (16.2%), from the pharynx - 15 (3.6%), from the blood - 9 (2.2%).

Keywords: purulent-inflammatory diseases, *Enterococcus faecalis*, antibiotic resistance, microbiological research, biological samples, urine, wound, throat, blood.

1. Introduction

Enterococci are representatives of the normal microbiota of the human intestine and urogenital tract. They can also be released from the nasopharynx, upper respiratory tract, and skin surfaces. Most infections caused by enterococci are endogenous and result from the invasion of microorganisms due to excessive colonization of mucosal and skin surfaces [1,2]. Enterococci often cause urinary tract infections in patients with long-term functioning catheters, and they are responsible for 10-20% of all bacterial endocarditis cases and 5% of bacteremias [3,4]. Despite being normal inhabitants of the human microbiota, under certain conditions, enterococci can induce the development of infectious-inflammatory processes. The clinical manifestations of enterococcal infections are diverse, ranging from localized infections (urinary tract infections, wounds) to generalized forms (bacteremia, bacterial endocarditis, meningitis) [5,6,7].

In recent years, more and more attention has been paid worldwide to the problem of antibiotic-resistant bacterial strains, particularly *Enterococcus faecalis*, and their role in the development of purulent-inflammatory diseases in humans [8,9,10,11,12,13]. This is due to the increasing concern over the rising number of infections caused by antibiotic-resistant *E. faecalis* strains.

Enterococcus faecalis is one of the most common microorganisms inhabiting the human intestine. Typically, it is a harmless bacterial symbiont, but some strains exhibit antibiotic resistance, which makes them potentially dangerous to human health [14,15,16]. Their presence can lead to infections such as appendicitis, peritonitis, sepsis, as well as inflammatory diseases of the urinary tract and skin [17,18]. Antibiotic-resistant strains of *Enterococcus faecalis* can be particularly dangerous for immunocompromised patients, such as those undergoing surgical procedures, with oncological diseases, or receiving immunosuppressive therapy [8,12,18].

Study objective: To investigate the frequency of *Enterococcus faecalis* inoculation from clinical biological samples of patients with purulent-inflammatory diseases over the period from 2018 to 2022 in a non-infectious clinics.

2. Materials and Methods

A retrospective analysis of five-year data from 2018 to 2022 was conducted. The data included results of bacteriological studies to identify pure cultures of *E. faecalis* in the microbiological laboratory of «National Scientific Medical Center» JSC, Astana.

Clinical material for bacteriological research was collected at «National Scientific Medical Center» JSC. The biological material came from patients with purulent-inflammatory diseases. The samples were collected and transported to the microbiological laboratory according to methodological guidelines.

Cultivation of Samples. The primary inoculation of clinical material was performed quantitatively on nutrient media according to regulatory documents [7]. The quantitative analysis of the material was carried out using nutrient media (blood agar, Endo agar, enterococcal agar, Kalina agar). The inoculations were cultured for 24 hours at 37°C.

Identification of Isolates. According to methodological recommendations, the morphological and cultural properties, Gram staining, oxidase and catalase tests, and indole production tests were studied for the identification of isolates. The final identification of isolated pure cultures was conducted using the microbiological «Vitek 2 – Compact» analyzer (bioMerieux, Marcy I'Etoile, France) [8].

Statistical processing of the obtained data was performed using Microsoft Excel. The mean value, standard error, and dynamic changes were determined using linear regression. Differences in means were considered statistically significant at $p<0.05$.

3. Results and Discussion

According to the data from the microbiological laboratory of the «National Scientific Medical Center» JSC, from 2018 to 2022, a total of 414 *Enterococcus faecalis* isolates were obtained from various clinical materials from patients with purulent-inflammatory diseases, among other pathogenic microorganisms.

In 2018, 103 *Enterococcus faecalis* strains were isolated from the 414 total isolates. Analysis of the data on the various biological materials from which enterococci were isolated during the study period showed that, in 2018, the highest frequency of *Enterococcus faecalis* isolation was from urine, accounting for 36.9% of the strains, then wounds - 22.3%, then the throat - 6.8%, sputum - 5.8%, and bronchial lavage fluids, umbilical cord, and urinary catheter - 3.9% each, from the TBD catheter and abdominal cavity - 2.9% of strains. From the central venous catheter and blood for sterility - 1.9%. Additionally, one strain was isolated from the nose, ear, tracheostomy, and episiotomy.

For 2019, data show that a total of 71 strains were isolated. The inoculation rate from urine was 49.3% of strains, from the wound - 11.3%, and from blood - a total of 5.6% of strains were isolated. From the remaining materials, a minimal amount of *Enterococcus faecalis* was isolated.

In 2020, a total of 94 *Enterococcus faecalis* strains were isolated. Data from 2020 show an increase in isolation frequency, with 49% of the strains isolated from urine, 10.6% from wounds, and 3.2% from the throat. Minimal amounts of *Enterococcus faecalis* were isolated from other materials.

In 2021, 83 *Enterococcus faecalis* strains were isolated. The highest frequency of isolation was from urine, accounting for 56.6%, followed by wounds at 24.1%. Minimal amounts of *Enterococcus faecalis* were isolated from other materials.

In 2022, a total of 63 *Enterococcus faecalis* strains were isolated. The data show a continued increase in isolation from urine, which accounted for 77.8% of the strains. Isolation from wounds decreased to 9.5%, while isolation from the throat was 4.8%. Minimal amounts of *Enterococcus faecalis* were isolated from other materials.

The frequency of *Enterococcus faecalis* inoculation from various samples is reflected in Table 1.

Table 1 - Quantitative data on the isolation of *Enterococcus faecalis* in a non-infectious clinic from 2018 to 2022

"Research materials	**Urine**		**Wound**		**Throat**		**Blood**	
Years	n	%M±m	n	%M±m	n	%M±m	n	%M±m
2018 г.	38	36,8±7,82	23	22,3±8,68	7	6,8±9,4	2	1,9±9,6
2019 г.	35	49,3±8,45	8	11,3±11,1	1	1,4±11,74	4	5,6±11,66
2020 г.	46	49±7,37	10	10,6±10,21	3	3,2±10,00	1	1,0±9,94
2021 г.	47	56,6±7,22	20	24,1±9,54	1	1,2±10,88	1	1,2±10,88
2022 г.	49	77,8±5,94	6	9,5±11,97	3	4,8±12,34	1	1,6±12,54
Total	**215**	**51,9±3,40**	**67**	**16,2±4,50**	**15**	**3,6±4,80**	**9**	**2,2±4,9**

As shown in Table 1, the highest number of *Enterococcus faecalis* inoculations were obtained from the following materials: urine, wound, throat swab, and blood.

Thus, according to the data from the microbiological laboratory of the «National Scientific Medical Center» (NSMC), a total of 414 strains of enterococci were isolated from clinical materials with purulent-inflammatory diseases of various localizations over the period from 2018 to 2022. When analyzing the dynamics of the increase or decrease in the number of isolates by year, it can be noted that the most significant increase in the number of enterococci was observed only in samples taken from urine – 51.9% (Table 1).

The second highest frequency of *Enterococcus faecalis* isolation is observed from wounds, accounting for 16.2% of the strains. In comparison, 3.6% of strains were isolated from the throat, while only 2.2% of strains were isolated from blood cultures for sterility. The dynamics of the increase or decrease in *Enterococcus faecalis* inoculation from various samples between 2018 and 2022 are shown in Table 1.

The diagram illustrating the dynamics of *Enterococcus faecalis* inoculation from different samples during the period of 2018-2022 is presented in Figure 1.

Analyzing the results shown in Figure 1, it can be confirmed that there is a noticeable trend of increased isolation of *Enterococcus faecalis* from urine from 2018 to 2022. In 2018, the frequency of *Enterococcus faecalis* detection was 36.8%, whereas by 2022, the frequency of isolation from urine had increased to 77.8%.

In 2018, the isolation rate from wounds was 22.3%, and by 2021, there was a significant increase to 24.1%. However, during 2019, 2020, and 2022, the isolation rates from wounds showed a decrease.

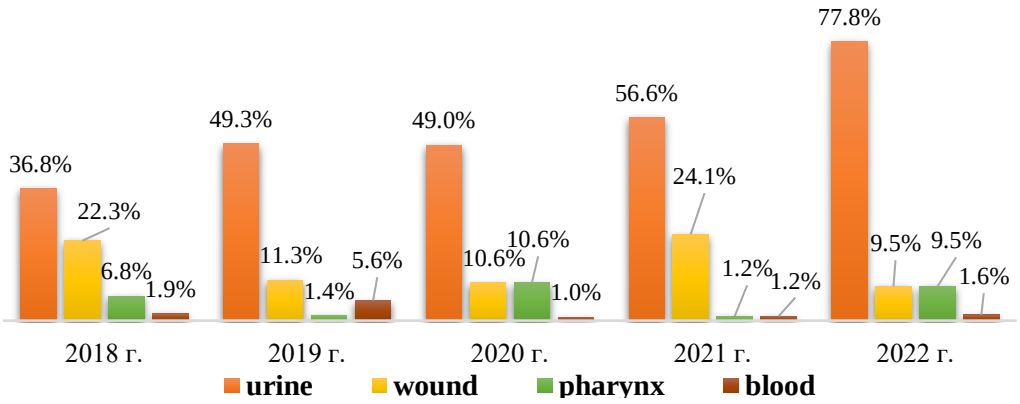

Figure 1 - Dynamics of *Enterococcus faecalis* isolation from various samples from 2018 to 2022

The results of our study on the frequency of Enterococcus faecalis inoculation, based on data from the National Scientific Medical Center JSC for patients with purulent-inflammatory diseases from 2018 to 2022, showed that over the past decades, the number of Enterococcus faecalis inoculations from urine has increased, which is consistent with findings from international authors. In the study by Polish authors - Olga Maria Rostkowska et al. (2020), it was noted that Enterococcus faecalis was most frequently isolated from the urine of patients in the intensive care unit, with an 8-year study period showing a 24% isolation rate (128 strains)【19】.

According to a scientific study by Russian authors, which assessed the role of enterococci as pathogens of postoperative infectious complications, 465 strains of enterococci were isolated, with the highest number of Enterococcus faecalis isolated from urine (47.7%) and from the throat (24.3%), and enterococcal bacteremia was recorded in 9.7%, which corresponds to our data【20】. However, in the study, wound infections caused by enterococci accounted for only 3%, while in our study it accounted for 16.2%.

4. Conclusion

Based on the analysis of the dynamics of Enterococcus faecalis isolates inoculation from various clinical samples from patients with purulent-inflammatory diseases in a non-infectious clinic, the following conclusions can be drawn:

1. During the studied period, the highest level of Enterococcus faecalis inoculation was observed in 2018 (24.9%), and the lowest level of inoculation was observed in 2022 (15.2%).

2. The frequency of Enterococcus faecalis inoculation during the studied period, depending on the patient's biomaterial, varied as follows: it was isolated from urine in 215 cases (51.9%), from the wound - 67 (16.2%), from the pharynx - 15 (3.6%), from the blood - 9 (2.2%).

Acknowledgements. We are grateful to the participants for making this study possible, as well as to ll the staff of the microbiological laboratory of JSC "National Scientific Medical Center" Astana.

Authors' Contributions. Rakhmetova N.B. - development of the general concept of the study, collection, analysis of the results obtained;

Bisenova N.M. - development of study design; making a final decision on the readiness of the manuscript for publication, collection and analysis of clinical data, drafting the manuscript, interpretation of data. Sarsenova A.G. - A. - statistical processing of the material, analysis of statistical results, text editing

Conflict of Interest: the authors declare no conflicts of interest.

Funding: This research is not funded by any organizations or individuals.

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Инфекциялық емес клиникадағы іріңді-қабыну ауруы бар пациенттердің әр түрлі клиникалық үлгілерінен Enterococcus Faecalis изоляттарының бөлініп алыну жиілігі

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Түйіндеме

Кіріспе. Соңғы жылдары бүкіл әлемде антибиотиктерге төзімді бактерия штаммдары, әсіресе *Enterococcus faecalis*-тың антибиотиктерге төзімділігінің артуы және олардың адамның іріңді-қабыну ауруларының дамуындағы рөліне көңіл бөлу артуда. Бұл *E. faecalis*-тың антибиотикке төзімді штамдарынан туындаған инфекциялар санының алаңдатарлық өсуімен байланысты, сондықтан оларды инфекциясыз клиникаларда емделген науқастардан бөліну жиілігін зерттеу маңызды болып табылады.

Зерттеу мақсаты. 2018 жылдан 2022 жылға дейінгі кезеңде инфекциясыз клиникада іріңді-қабыну аурулары бар науқастардан алынған клиникалық биологиялық үлгілерден *Enterococcus faecalis* бактериясын бөліп алу жиілігін бағалау.

Зерттеу әдістері. 2018-2022 жылдар аралығында *Enterococcus faecalis*-тың таза культураларының бактериологиялық зерттеу деректері бойынша Ретроспективті талдау жүргізілді. Статистикалық өңдеу Microsoft Excel бағдарламасын пайдалана отырып жүргізілді, онда орташа мән, қателік және сызықтық регрессия әдісімен динамикалық өзгерістер талданды. Айырмашылықтар статистикалық тұрғыдан маңызды деп қабылданды ($p<0,05$).

Нәтижелер. 2018-2022 жылдар аралығында әртүрлі клиникалық үлгілерден 414 *Enterococcus faecalis* изоляты алынды. Ең көп штаммдар зәрден (51,9%) алынды, содан кейін жаралардан (16,2%), жұтқыншақтан

(3,6%) және қаннан (2,2%) бөлінді. 2018 жылы зәрден штаммдар үлесі 36,8%-ды құраса, 2022 жылға қарай бұл көрсеткіш 77,8%-ға өскен.

Enterococcus faecalis изоляттарының іріңді-қабыну аурулары бар науқастардан инфекциясыз клиникада алынған әртүрлі клиникалық үлгілер бойынша бөліну динамикасын қорытындылай отырып, зерттеу кезеңі барысында ең жоғары бөліну көрсеткіші 2018 жылы (24,9%) байқалғанын, ал ең төменгі көрсеткіш 2022 жылы (15,2%) тіркелгенін атап өттік. Сонымен қатар, *Enterococcus faecalis* бөліну жиілігі пациенттің биоматериалына байланысты келесідей өзгерді: зәрден 215 рет (51,9%), жарадан 67 рет (16,2%), жұтқыншақтан 15 рет (3,6%), қаннан 9 рет (2,2%) бөлінген.

Кілт сөздер: іріңді-қабыну аурулары, *Enterococcus faecalis*, антибиотикке төзімділік, микробиологиялық зерттеулер, биоматериалдар, зәр, жара, жұтқыншақ, қан.

Частота высеваемости изолятов Enterococcus Faecalis из различных клинических образцов от больных с гнойно-воспалительными заболеваниями в неинфекционной клинике

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Резюме

Введение. В последние годы во всем мире растет внимание к проблеме антибиотикорезистентных штаммов бактерий, в частности *Enterococcus faecalis*, и их роли в развитии гнойно-воспалительных заболеваний у человека. Это вызвано тревожным ростом случаев инфекций, вызванных антибиотикорезистентными штаммами *E. faecalis*, что делает актуальным изучение частоты их высеваемости у больных, госпитализированных в неинфекционные клиники.

Цель исследования. Оценить частоту высеваемости *Enterococcus faecalis* из клинических биоматериалов у больных с гнойно-воспалительными заболеваниями в неинфекционной клинике за период с 2018 по 2022 годы.

Методы исследования. Проведен ретроспективный анализ данных бактериологического исследования чистых культур *E. faecalis* в микробиологической лаборатории АО «Национальный научный медицинский центр» (г. Астана) за период с 2018 по 2022 годы. Статистическая обработка данных осуществлялась с использованием Microsoft Excel, включая определение средней величины, ошибки средней, а также анализ динамических изменений методом линейной регрессии. Различия считались статистически достоверными при $p<0,05$.

Результаты. В период с 2018 по 2022 годы было выделено 414 изолятов *Enterococcus faecalis* из различных клинических материалов. Наибольшее количество штаммов было получено из мочи (51,9%), за ней следуют рана (16,2%), зев (3,6%) и кровь (2,2%). Примечательно, что в 2018 году доля штаммов из мочи составляла 36,8%, а к 2022 году увеличилась до 77,8%.

Выводы. На основании анализа динамики высеваемости изолятов *Enterococcus faecalis* из различных клинических образцов от больных гнойно-воспалительными заболеваниями в неинфекционной клинике можно сделать следующие выводы:

1. За изученный период исследования самый высокий уровень высеваемости *Enterococcus faecalis* отмечался в 2018 году (24,9%), а самый низкий уровень высеваемости в 2022 году (15,2%).

2. Частота высеваемости *Enterococcus faecalis* за исследуемый период в зависимости от биоматериала пациента варьировала следующим образом: из мочи выделялся в 215 случаев (51,9%), из раны 67 раз (16,2%), из зева 15 раз (3,6%), из крови – 9 (2,2%).

Ключевые слова: гнойно-воспалительные заболевания, *Enterococcus faecalis*, антибиотикорезистентность, микробиологические исследования, биоматериалы, моча, рана, зев.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj004

Morphological changes in the oral mucosa during orthopedic treatment with removable plastic constructions

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Received: 09.05.2025
Accepted: 28.06.2025
Published: 31.10.2025

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Резюме

Background. Removable plastic dentures (RPDs) remain essential for edentulous patients, yet their interaction with oral tissues can precipitate inflammatory and degenerative changes that compromise both comfort and treatment longevity.

Objective. To quantify and characterise morphological alterations of the oral mucosa in long-term RPD wearers and to determine the influence of prosthesis quality, hygiene practices and duration of use on the severity of these changes.

Methods. A cross-sectional clinical study was performed on 65 patients aged ≥50 years who had worn complete or partial RPDs for at least 12 months. Standardised intra-oral examinations assessed colour, texture, exudation and lesion type; tongue coating and salivary moisture were also recorded. Prosthesis fit and surface roughness were determined by visual and tactile inspection. Oral hygiene habits were documented with a validated questionnaire. Eleven patients consented to punch biopsy for histopathological confirmation. Participants were stratified into groups with and without mucosal lesions. Associations were analysed using χ^2 and Student's t-tests ($\alpha = 0.05$).

Results. Forty-five patients (69%) showed clinically obvious mucosal damage: catarrhal inflammation (34/65, 52%), hyperplastic growths (11/65, 17%) and acrylic intolerance (2/65, 3%). Lesions correlated strongly with inadequate hygiene ($p < 0.01$) and low-quality dentures ($p = 0.02$). Wear time exceeding five years doubled the risk of pathology (OR = 2.1; 95% CI 1.1–3.9). Histology corroborated chronic inflammatory infiltration and epithelial degenerative changes.

Conclusion. Poorly fabricated or poorly maintained RPDs markedly increase the prevalence of pathological mucosal reactions. Regular professional follow-up, patient-centred hygiene education and timely remanufacture are pivotal for preserving oral tissue health.

Keywords: oral mucosa, dentures, inflammation, biofilms, mouth diseases.

1. Introduction

Removable plastic dentures are a practical solution for restoring masticatory function and facial aesthetics in patients with partial or complete tooth loss. However, despite their benefits, long-term use often leads to complications in the oral cavity. According to clinical observations, up to 70 % of denture wearers experience various forms of mucosal pathology, including catarrhal inflammation, trauma-induced lesions, hyperplasia and acrylic intolerance. The expanding elderly population and growing prevalence of edentulism make prevention and timely management of these complications particularly relevant. The present study aims to fill gaps in local epidemiological data by examining the prevalence and determinants of mucosal changes among denture wearers in Kazakhstan.

2. Materials and Methods

Study design: Cross-sectional observational study.

Participants: Sixty-five patients (34 females, 31 males; mean age 63 ± 8 years) attending dental clinics in Astana who had worn complete or partial removable plastic dentures for ≥12 months. Inclusion criteria: signed informed consent, adequate general health, and willingness to undergo biopsy if indicated. Exclusion criteria: recent chemotherapy, immunosuppression, uncontrolled diabetes, and systemic diseases affecting the oral mucosa.

Clinical protocol: Standardised examination recorded mucosal colour, swelling, surface characteristics, and lesions. Tongue coating and salivary moisture were also assessed. Prosthesis quality was judged by fit, stability, occlusal scheme and base roughness. Hygiene was evaluated via questionnaire and direct observation of denture cleanliness.

Histopathology: Punch biopsies (3 mm) were obtained from 11 symptomatic sites under local anaesthesia and examined with H&E staining.

Statistics: Data were analysed using SPSS 28.0. Continuous variables were compared using Student's t-test; categorical variables with χ^2-test. Significance was set at $p<0.05$.

Ethics: The study complied with the Declaration of Helsinki and was approved by the Local Ethics Committee (protocol № 2024-04).

3. Results

Lesion prevalence: Mucosal changes were observed in 45 of 65 participants (69 %). The distribution of lesions was: catarrhal inflammation – 52 % (n=34), hyperplastic processes – 17 % (n=11), acrylic intolerance – 3 % (n=2).

Risk factors: Poor hygiene practices were present in 45 patients (69 %) and were strongly associated with inflammatory lesions ($\chi^2 = 10.5$, $p<0.01$). Low-quality prostheses were identified in 37 cases (57 %) and correlated with lesion presence ($\chi^2 = 5.6$, $p=0.02$). Denture wear exceeding five years increased lesion risk two-fold (OR = 2.1, 95 % CI 1.1–3.9).

Histological findings: Specimens showed chronic inflammatory infiltrates, epithelial atrophy or hyperplasia, and micro-ulceration corresponding to clinical diagnoses.

4. Discussion

Our findings align with previous international studies that report mucosal complication rates between 60 % and 75 % among long-term denture wearers. The high prevalence of catarrhal inflammation highlights the mechanical trauma caused by poorly fitting prostheses and the irritative effect of plaque biofilms. Hyperplastic lesions, particularly lobular fibromas and papillary hyperplasia, likely develop from chronic low-grade trauma combined with Candida colonisation.

The strong association between inadequate hygiene and lesion severity underscores the need for structured patient education. Digital fabrication techniques and high-impact acrylics have been shown to improve fit and reduce surface roughness; their wider adoption could mitigate trauma-related pathology.

Limitations of our study include its cross-sectional nature, reliance on clinical assessment for most participants, and relatively small biopsy sample. Future longitudinal studies incorporating microbiological profiling and patient-reported outcome measures are warranted.

5. Conclusions

1. Pathological changes of the oral mucosa were detected in 69 % of removable denture wearers examined.

2. Inadequate denture hygiene and low-quality prostheses are significant, independent risk factors for mucosal lesions.

3. Wearing dentures for more than five years doubles the risk of pathological tissue changes.

4. Regular professional follow-up, timely remanufacture of prostheses and comprehensive hygiene education are essential preventive strategies.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

The authors thank the staff of NJSC "Medical University Astana" dental clinics for assistance with patient recruitment.

Funding

The study received no external funding.

Author Contributions

Conceptualization - M.K.Z.; Investigation - R.N.Z.; Formal analysis - R.N.Z., E.B.K., S.A.A.; Writing - original draft - M.K.Z.; Writing - review and editing - R.N.Z., Supervision - M.K.Z. All authors have read and approved the final manuscript.

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Алынбалы пластикалық конструкциялармен ортопедиялық емдеу кезінде ауыз қуысының шырышты қабығындағы морфологиялық өзгерістер

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Түйіндеме

Өзектілігі. Алынбалы пластикалық протездер тіссіз науқастардың функциясы мен эстетикасын қалпына келтірудің кең таралған әдісі, алайда ұзақ қолданылуы ауыз шырышты қабығында қабыну өзгерістерін туындатады.

Зерттеудің мақсаты. Протез сапасы, гигиеналық дағдылар және пайдалану ұзақтығының шырышты қабық морфологиясына әсерін бағалау.

Әдістері. Астана қаласындағы 65 пациентке (≥50 ж.) клиникалық тексеру, гигиена сауалнамасы, биопсия (11 пациент) жүргізілді; деректер χ^2 және t-тесттерімен талданды.

Нәтижесі. Пациенттердің 69 %-ында шырышты қабық зақымдары анықталды; зақымданулардың жиілігі нашар гигиена ($p<0,01$) және сапасыз протездермен ($p=0,02$) сенімді байланыс көрсетті.

Қорытынды. Сапасыз немесе дұрыс күтім жасалмаған протездер шырышты қабық патологиясының қаупін арттырады; тұрақты бақылау және пациенттерді оқыту қажет.

Түйін сөздер: ауыз шырышты қабығы, протездер, қабыну, биофильм, ауыз аурулары.

Морфологические изменения слизистой оболочки полости рта при ортопедическом лечении съемными пластиковыми конструкциями

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Резюме

Актуальность. Съемные пластмассовые протезы широко применяются для восстановления функции и эстетики полости рта, однако длительное ношение может вызывать воспалительные и дистрофические изменения слизистой оболочки.

Цель исследования. Оценить морфологические изменения слизистой у пациентов, пользующихся протезами, и установить влияние качества протеза, гигиены и длительности ношения.

Методы. Обследовано 65 пациентов (≥50 лет) с полными и частичными протезами; проведены клинический осмотр, опрос гигиены, гистологическое исследование (11 случаев); статистический анализ χ^2 и t-тесты.

Результаты. У 69 % пациентов выявлены поражения слизистой; их частота достоверно связана с неудовлетворительной гигиеной ($p<0,01$) и низким качеством протезов ($p=0,02$).

Выводы. Некачественные или плохо обслуживаемые протезы повышают риск патологических реакций; необходимы регулярный контроль и обучение гигиене.

Ключевые слова: слизистая полости рта, протезы, воспаление, биоплёнка, заболевания полости рта.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj005

Сравнение частоты демпинг – синдрома после гастрошунтирования по методу ФундоРинг по данным контрастного рентгенологического исследования, определения уровня инсулина и результатов глюкозотолератного теста

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Received: 13.02.2025
Accepted: 25.04.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj005.

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Резюме

Введение. Одноанастомозное желудочное шунтирование (ОАГШ) - эффективный метод лечения ожирения. Однако частота демпинг-синдрома (ДС) после операции остаётся актуальной проблемой. Предложен модифицированный метод - ФундоРинг, включающий фундопликацию с использованием отключённого желудка, как способ снижения частоты ДС.

Методы. Было проведено одноцентровое, рандомизированное контролируемое исследование с участием 1000 пациентов (500 в группе ФундоРинг ОАГШ (ф-ОАГШ) и 500 в группе стандартного ОАГШ (с-ОАГШ)). Частота ДС оценивалась по результатам перорального глюкозотолерантного

теста, уровню инсулина и рентгенологическим признакам скорости опорожнения желудочного кармана.

Результаты. Частота демпинг-синдрома через год составила 19,6% в группе ф-ОАГШ и 35% в группе с-ОАГШ (p=0,001). Поздние проявления ДС и тяжёлые степени встречались достоверно реже в группе ф-ОАГШ. Также наблюдалось более плавное повышение и снижение уровня глюкозы и инсулина у пациентов с фундопликацией. Рентгенологически выявлено замедленное опорожнение желудочного кармана и более длительное прохождение бария по тонкому кишечнику в группе ф-ОАГШ.

Вывод. ФундоРингОАГШ надёжно снижает частоту и тяжесть демпинг-синдрома по сравнению с традиционным ОАГШ и может быть рекомендован для более широкого клинического применения.

Ключевые слова: демпинг-синдром, ФундоРинг, одноанастомозное желудочное шунтирование, бариатрическая хирургия, глюкозотолерантный тест, инсулин, контрастная рентгенография, ожирение, фундопликация.

1. Введение

Одноанастомозное желудочное шунтирование (ОАГШ) является более простой и безопасной процедурой, чем гастрошунтирование по Ру (ГШРу) для лечения пациентов с ожирением; поэтому оно все чаще применяется в мировой практике, занимая третье место по частоте применения среди бариатрических операций. Одним из преимуществ ОАГШ является более низкая частота демпинг-синдрома (ДС) [1]. В предыдущем исследовании сообщалось, что частота ДС составила 42,9% после ОАГШ по сравнению с 56,4% после ГШРу. Однако частота возникновения краевых язв была значительно выше у пациентов, перенесших ОАГШ, чем у тех, кто перенес ГШРу [2]. Исследования также показали, что удлинение желудочного кармана снижает частоту демпинг-синдрома с 60% до 49%; однако одновременно увеличивает частоту возникновения анастомозных язв с 2,6% до 12,4% [3]. Более того, гастроэзофагеальный анастомоз также вызывает демпинг синдром, особенно его ранний вариант [4]. Демпинг синдром возникает не только при гастрошунтировании, но и при продольной резекции желудка (ПРЖ) у 26,5% пациентов по сравнению с 41,4% после шунтирования желудка по Ру [5].

Демпинг синдром подразделяется на ранний и поздний типы. Ранний демпинг обычно развивается в течение первых 60 минут после еды, вероятно, из-за гиперосмолярности пищи, которая вызывает быстрое перемещение жидкости из плазменного компартмента в просвет кишечника. Смещение жидкости частично объясняет ранний демпинг-ответ сердечно-сосудистой системы. Перемещение жидкости в тонкую кишку при демпинге может вызывать вздутие живота и способствовать спазматическим сокращениям, вздутию живота и диарее. Кроме того, высвобождение нескольких желудочно-кишечных гормонов, включая вазоактивные вещества, инкретины и модуляторы глюкозы, вызывает желудочно-кишечные симптомы и гемодинамические эффекты на ранних стадиях демпинга [6]. Ранний демпинг является типичным и наиболее частым проявлением и может возникать изолированно или в сочетании с симптомами позднего демпинга. В тяжелых случаях сопровождается значительным снижением качества

жизни и дополнительной потерей веса. Поздний демпинг проявляется гипогликемией и адренергическими реакциями через 60–180 минут после еды. В этом случае пациенты испытывают сильную слабость, утомляемость, полуобморочное состояние, потливость и тремор [7]. Кроме того, симптомы позднего демпинга связаны с нейрогликопенией (проявляющейся утомляемостью, слабостью, спутанностью сознания, чувством голода и обмороками) и вегетативной и/или адренергической реактивностью (проявляющейся потливостью, сердцебиением, тремором и раздражительностью). Пероральный глюкозотолерантный тест (ПГТТ) и анализ симптомов демпинг-синдрома более эффективны для оценки скорости опорожнения оперированного желудка по сравнению с рентгенологическими или другими методами, такими как тесты на опорожнение желудка, которые обладают низкой чувствительностью и специфичностью при синдроме демпинга [8]. Вместе с тем, рентгенологическое исследование так же дает важную информацию, при которой для демпинг-синдрома характерны быстрое опорожнение культи желудка от принятого контрастного вещества, значительное усиление перистальтики тонкой и толстой кишки, сменяющееся инертностью.

В доступной литературе представлены противоречивые результаты по влиянию технических конструктивных особенностей малого желудочка на проявления демпинг синдрома. Например, в некоторых исследованиях утверждается, что длинный размер малого желудочка значительно снижает вероятность развития демпинг-синдрома и является оптимальным решением этой проблемы, в других работах указывается, что демпинг синдром — это неотъемлемый побочный эффект быстрого опорожнения после бариатрической операции на желудке. Мы предположили, что использование «живого кольца», использующего дно отключенной части желудка, с созданием фундопликации на пищеводе и части малого желудка может снизить частоту возникновения демпинг синдрома.

Целью данного исследования было сравнение частоты раннего и позднего демпинг синдрома после применения метода «Фундоринг» и стандартного анастомозного желудочного шунтирования путем оценки перорального глюкозотолерантного теста, уровня инсулина и рентгенологической оценки скорости эвакуации из малого желудочка.

2. Материалы и методы

Дизайн исследования

Это одноцентровое, проспективное, интервенционное, открытое рандомизированное контролируемое исследование (РКИ) было проведено в Медицинском университете г. Астаны, и все операции были выполнены одним хирургом в «Центре хирургии им. профессора Орала Оспанова». Протокол исследования был опубликован ранее и зарегистрирован под номером NCT04834635 в базе данных ClinicalTrials.gov 8 апреля 2021 года. Для составления отчета об этом исследовании использовались контрольный список CONSORT и блок-схема для РКИ [10].

Участники

Включение и исключение

Критерии включения

- Ожирение I–III степени (индекс массы тела [ИМТ, кг/м²] 30,0–50,0).
- Приемлемый операционный риск (ASA 1–2).
- Пациенты в возрасте 18–60 лет.

Критерии исключения

- Пациенты с предшествующей хиатальной герниорафией и фундопликацией.
- Гигантская грыжа пищеводного отверстия диафрагмы (ГПОД) >5 см (или ≥30,0% желудка, находящегося в грудной клетке).
- Рефлюкс-эзофагит C или D (по классификации Лос-Анджелеса [LA]).
- Пациенты после бариатрической операции.

Рандомизация и распределение по группам

Пациенты, соответствующие критериям включения и не соответствующие критериям исключения, были последовательно включены и рандомизированы в одну из двух групп исследования статистиком исследования, который участвовал только в рандомизации и статистическом анализе. Список рандомизации хранился строго конфиденциально, а сокрытие распределения обеспечивалось с помощью последовательно пронумерованных, идентичных, непрозрачных, запечатанных конвертов. Вмешательство назначалось каждому пациенту случайным образом во время предпроцедурного визита медсестрой, которая не участвовала в наборе или оценке пациентов.

Методы операций

Мы применяли в первой (основной) группе гастрошунтирование по методу ФундоРинг ОАГШ (ф-ОАГШ) [11]. Она включала лапароскопическую ОАГШ, дополненной циркулярной фундопликацией пищевода и желудка. Операцией в контрольной группе была стандартная лапароскопическая МГШ/ОАГШ (с-ОАГШ), описанная Carbajo и соавт. [12].

Размер гастроэнтероанастомоза был одинаковым в обеих группах и создавался интраоперационно с помощью линейного степлера EndoGIA с 45-миллиметровой фиолетовым картриджем Tri-Staple™ (Medtronic, США). После ушивания окна анастомоза (дефекта) диаметр гастроэнтероанастомоза составлял 30–35 мм. При послеоперационной эндоскопии через 1 год размер гастроэнтероанастомоза оценивался в диапазоне от 20 до 25 мм [11, 13].

Выбор срока наблюдения

Согласно литературным данным, симптомы демпинг-синдрома могут проявляться в течение от 1 до 36 месяцев. Однако в большинстве публикаций указывается начало симптомов в среднем через 12 месяцев [14, 15]. Поэтому в нашем исследовании мы оценили частоту и выраженность симптомов через 1 год.

Показатели эффективности

Пероральные тесты на толерантность к глюкозе

В ходе 3-часового ПГТТ пациенты с подозрением на демпинг синдром принимали 75 г раствора глюкозы после ночного голодания. Концентрация глюкозы в крови, уровень гематокрита, частота пульса и артериальное давление измерялись до приема пищи и с 30-минутными интервалами в течение 180 минут после приема пищи. ПГТТ считался положительным для раннего демпинг синдрома при наличии раннего (30 минут) повышения уровня гематокрита > 3% или увеличения частоты пульса > 10 уд./мин через 30 минут после приема пищи. ПГТТ считался положительным для позднего демпинг синдрома при развитии поздней (через 60, 90, 120 и 180 минут после приема пищи) гипогликемии (< 50 мг/дл (< 2,8 ммоль/л)). Спонтанный уровень глюкозы в плазме (50 мг/дл) указывал на позднюю стадию демпинг синдрома.

Инсулин

Кровь собирали для оценки уровня инсулина на 0, 30, 60, 90, 120, 150 и 180-й минуте. Пиковый уровень глюкозы был наивысшим во время ПГТТ. Минимальный уровень глюкозы определялся как самый низкий уровень глюкозы после пикового.

Контрастное рентгенологическое исследование пищевода, малого желудочка и тонкой кишки с серией снимков

Пациент на тощак одномоментно выпивал 50 мл жидкой водной взвеси сульфата бария. Оценивали акт глотания, прохождение контрастной массы по пищеводу, состояние пищеводно-желудочного перехода. Затем изучали положение, форму, размер и контуры малого желудка, его тонус и перистальтику. Особое внимание уделяли хронометрии процесса опорожнения из малого желудочка бария, оценивали состояние гастроэнтероанастомоза и скорость прохождения бария по тонкой кишке.

Фиксацию показателей процесса опорожнения из малого желудочка бария проводили на 1, 10, 15, 20, 30, 60 минутах. Где определяли объём опорожнения малого желудочка в течении 1 минуты

(порция), затем уточняли полную эвакуацию бария из малого желудочка. Время прохождения тонкого кишечника контрастным веществом определяли через 4, 5, 6 часов. Останавливали рентгенологическое исследование при получении минимально необходимой информации без излишнего дублирования.

Стадии (степени) тяжести демпинг синдрома

Демпинг-синдром I степени – это легкая форма заболевания, которая характеризуется слабовыраженными и непродолжительными (10–15 мин) приступами слабости или недомогания после приема сладкои® пищи и молока. Если пациент соблюдает диету и режим питания, то чувствует себя хорошо и вполне трудоспособен. Хотя недостатка питания нет, имеется дефицит массы тела до 3–5 кг. Пульс во время приступа ускоряется на 10 ударов в минуту, систолическое давление снижается на 5 мм рт. ст. Эвакуация бария из малого желудочка происходит в течение 15–20 мин. Время прохождения тонкого кишечника контрастным веществом длится не менее 5 часов.

Демпинг-синдром II степени определяется клиническими проявлениями среднеи® степени тяжести. Атаки могут возникать после приема любои® еды и длятся 30–40 мин, характеризуются большеи® степенью интенсивности. Стул неустоиⓇчивыиⓇ - диарея сменяется запором. Трудоспособность снижена. Пульс во время приступа увеличивается на 10-15 ударов, систолическое артериальное давление снижается на 5–10 мм рт. ст. Малый желудочек освобождается от контрастного вещества в течение 10–15 мин. Барии® проходит тонкии® кишечник не более чем за 3–3,5 часов.

Демпинг-синдром III степени – тяжелая форма заболевания. Симптомы возникают после каждои® еды и длятся 1,5–2 часа. Больные во время приступа вынуждены лежать, поскольку при попытке встать возникает обморок. Боязнь приема пищи и резкие нарушения в процессе пищеварения и усвоения пищи приводят больных к истощению (изнуряющии® понос). Трудоспособность значительно снижена. Во время демпинг-атаки пульс ускоряется на 15–20 ударов, систолическое давление снижается на 10–15 мм рт. ст. Малый желудочек опорожняется от бария в течение 5–7 мин. В тонком кишечнике барии® находится не более 2–2,5 часов.

Демпинг-синдром IV степени также относится к тяжелои® форме заболевания. У этои® категории больных к вышеописаннои® симптоматике присоединяются дистрофические изменения внутренних органов, кахексия, гипопротеинемия, онкотические отеки, анемия. Больные абсолютно нетрудоспособны, часто им необходим постороннии® уход.

Статистические методы

Статистический анализ проводился с использованием Microsoft Excel для Mac (Microsoft Corp., Редмонд, Вашингтон, США) и StatPlus MacPro (AnalystSoft Inc., Уолнат, Калифорния, США). Нормальность распределения переменных проверялась с помощью критерия Колмогорова–Смирнова. Количественные демографические и исходные переменные представлялись в виде средних значений и стандартных отклонений, а качественные переменные – в виде количества и процентов. Межгрупповые сравнения количественных переменных проводились с помощью t-критерия Стьюдента для независимых выборок, а внутригрупповые сравнения – с помощью t-критерия Стьюдента для парных выборок. Межгрупповые различия качественных переменных оценивались с помощью критерия хи-квадрат. Статистическая значимость была установлена на уровне $p < 0,05$.

3. Результаты

Распределение пациентов

В период с января 2021 года по декабрь 2024 года 1000 пациентов были случайным образом распределены в экспериментальную группу ф-ОАГШ (n=500) или контрольную группу с-ОАГШ (n=500).

Существенных различий между двумя группами по демографическим характеристикам или исходному ИМТ обнаружено не было (таблица 2).

Таблица 2 - Распределение по возрасту, полу, предоперационным антропометрическим показателям, периоду наблюдения и времени операции

Характеристики	ф-ОАГШ n=500	с-ОАГШ n=500	p-value
возраст (лет)	37 ± 7.7	40 ± 9.2	0.9
Женщины	421 (84.2%)	407 (81.4%)	0.6
ИМТ (кг/м2) предопер	40.13 ± 12.7	41.13 ± 11.6	0.8
ИМТ (кг/м2) постопер	27.0 ± 7.5	29.0 ± 6.6	0.04
Δ ИМТ (кг/м2)	13.1 ± 0.5	12.13 ± 0.4	0.03
Наблюдение (месяц)	12.2 ± 5.3	12.6 ± 7.2	0.9
Продолжительность операции (минут)	104 ± 17	98 ± 20	0.01

Значения представлены как среднее значение ± одно стандартное отклонение. ИМТ = индекс массы тела

ИМТ

Все пациенты (100%) прошли годичное наблюдение. ИМТ при последующем наблюдении достоверно различался между группами: группа с ф-ОАГШ составила 27,0 ± 7,5 против 29,0 ± 6,6 в группе с с-ОАГШ (p = 0,04) (таблица 2). ИМТ (кг/м²) составил 13,1 ± 0,5 в группе с ф-ОАГШ против 12,13 ± 0,4 в группе с с-ОАГШ (p = 0,03).

Глюкоза

Перед операцией уровень глюкозы в ПГТТ был одинаковым в обеих группах на 0, 30, 60, 90, 120, 150 и 180-й минуте (таблица 3, рисунок 1). Кроме того, гликемия натощак после операции (0 мин) достоверно не различалась между группами.

После ПГТТ уровень сахара резко возрос в обеих группах; однако пиковый уровень глюкозы на 60-й минуте был значительно выше в группе с-ОАГШ, чем в группе ф-ОАГШ. Более высокий уровень в группе с-ОАГШ был связан с отсутствием фундопликационного обертывания пищевода и верхней части желудочного кармана. Задержка эвакуации из желудочного кармана привела к задержке поступления большей части глюкозы в тонкий кишечник, что обусловило менее резкий подъем уровня глюкозы на 60-й минуте. Однако на 90-й минуте уровень глюкозы был выше в группе ф-ОАГШ за счет более плавного снижения. На 90-й минуте уровень сахара в группе с-ОАГШ был ниже, чем в группе ф-ОАГШ, и эта тенденция сохранялась на 120, 150 и 180 минуте. Через 120 минут уровень глюкозы у пациентов в группе с-ОАГШ снизился и приблизился к критическому уровню (<50 мг/дл), что привело к увеличению числа пациентов с демпинг синдромом.

В связи с достижением критически низкого уровня глюкозы 46 (9,2%) пациентов в группе с-ОАГШ и 18 (3,6%) пациентов в группе ф-ОАГШ не смогли продолжить ПГТТ через 150 и 180 минут из-за усиления симптомов позднего демпинг-синдрома.

Как показано в таблице 3 и на рисунке 1, уровень глюкозы через 180 минут в обеих группах был ниже предоперационного. Эта тенденция также наблюдалась в начале теста натощак на 0 минуте у пациентов, перенесших операцию, что мы связываем с долгосрочным эффектом бариатрической хирургии. Кроме того, относительно слабый инкретиновый эффект глюкозы перед бариатрической операцией привел к низким и более плоским пиковым уровням глюкозы у пациентов с ожирением в обеих группах в ответ на физиологически медленное поступление глюкозы в тонкий кишечник из-за прохождения пищи через толстый желудок и двенадцатиперстную кишку.

Таблица 3 - ПГТТ: Уровень глюкозы(мг/дЛ)

Мин ПГТТ	предопер-ф-ОАГШ	предопер-с-ОАГШ	предопер p-value	постопер-ф-ОАГШ	постопер-с-ОАГШ	p
0	105±17	106±13	NS	87±8	84±6	NS
30	131±23	134±19	NS	166±22	192±26	0.03
60	153±15	155±21	NS	182±31	209±19	0.02
90	149±24	150±26	NS	130±17	120±14	0.04
120	142±22	143±30	NS	110±12	73±7	0.001
150	126±17	128±13	NS	87±12	66±11	0.03
180	98±15	97±9	NS	75±11	60±5	0.04

Значения представлены как среднее значение ± одно стандартное отклонение

NS – статистически незначимо (p>0,05)

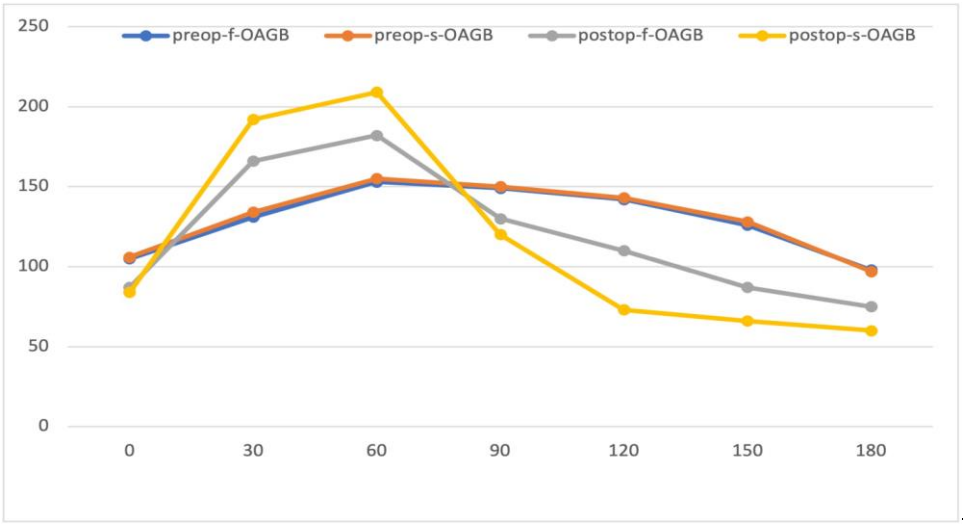

Рисунок 1 - Пероральные тесты на толерантность к глюкозе (ПГТТ): уровни глюкозы (мг/дл) в течение 0, 30, 60, 90, 120, 150, 180 мин.

Инсулин

До операции уровень инсулина в ПГТТ был одинаковым в обеих группах на 0, 30, 60, 90, 120, 150 и 180-й минуте (таблица 4, рисунок 2). Кроме того, уровень инсулина натощак после операции (0 мин) достоверно не различался между группами с-ОАГШ и ф-ОАГШ.

Таблица 4 - Уровень инсулина (pmol/L)

Мин ПГТТ	предопер-ф-ОАГШ	предопер-с-ОАГШ	предопер-value	постопер-ф-ОАГШ	постопер -с-ОАГШ	p
0	156±61	157±58	NS	48±10	49±8	NS
30	480±38	460±44	NS	768±13	978±27	0.01
60	484±41	450±66	NS	1100±89	1498±76	0.01
90	591±18	570±29	0.04	645±54	760±67	0.01
120	658±84	678±67	0.04	315±34	431±29	0.001
150	502±42	544±38	0.03	194±11	301±18	0.001
180	358±23	377±35	0.05	35±9	67±11	0.01

Значения представлены как среднее значение ± одно стандартное отклонение

NS – статистически незначимо (p>0,05)

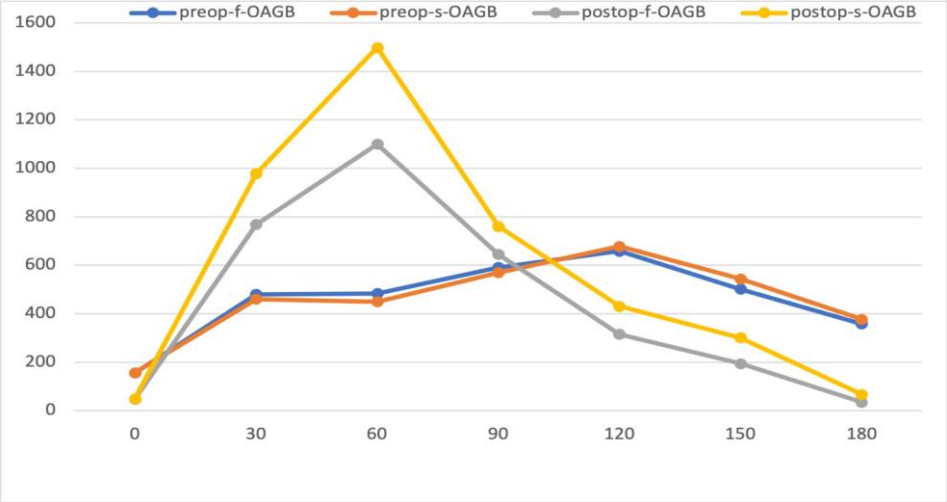

Рисунок 2 - Пероральные тесты на толерантность к глюкозе (ПГТТ): уровни инсулина (пмоль/л) в течение 0, 30, 60, 90, 120, 150, 180 мин.

Как показано в Таблице 4 и на Рисунке 2, уровень инсулина после бариатрической операции был значительно выше через 30 минут ПГТТ, а максимальное значение наблюдалось на 60-й минуте, что в несколько раз превышало предоперационное значение. Более того, пик инсулина в группе ф-ОАГШ превышал таковой в группе с-ОАГШ. Повышенный уровень инсулина в группе ф-ОАГШ сохранялся в течение 90–180 минут, что приводило к более высокой частоте позднего синдрома демпинга в группе ф-ОАГШ, чем в группе с-ОАГШ. Как показано на Рисунке 2, пик инсулина перед операцией у пациентов наблюдался через 120 минут после приема глюкозы, что на 1 час позже, чем у тех же пациентов, перенесших впоследствии бариатрическую операцию. Это может быть связано с физиологической задержкой поступления глюкозы в тонкую кишку и минимальным влиянием инкретинов.

Распространенность раннего и позднего демпинг-синдрома

Как показано в таблице 5, 175 из 500 (35%) пациентов в группе с-ОАГШ и 98 из 500 (19,6%) пациентов в группе ф-ОАГШ соответствовали критериям демпинг-синдрома.

Таблица 5 - Распространенность Демпинг-синдрома

Показатель	ф-ОАГШ n=500	с-ОАГШ n=500	p-value
Частота возникновения депинг-синдрома	98 (19.6%)	175 (35%)	0.001
1. ранние симптомы	24 (24.49%)	49 (28%)	0.07
2. поздние симптомы	32 (32.7%)	75 (42.86)	0.001
3.ранние и поздние симптомы	42 (42.8%)	51 (29.14)	0.01

Из 98 (19,6%) пациентов в группе ф-ОАГШ, соответствующих критериям демпинг- синдрома, 24 (24,49%) сообщили о ранних симптомах (таблица 5). Из 175 (35%) пациентов в группе с-ОАГШ, соответствующих критериям демпинг- синдрома, 49 (28%) сообщили о ранних симптомах. Статистически значимых различий между типами ОАГШ по раннему проявлению симптомов не наблюдалось (p > 0,07). В то же время у 32 (32,7%) и 75 (42,86%) пациентов с демпинг- синдромом в группах ф-ОАГШ

и с-ОАГШ соответственно отмечено позднее проявление симптомов.

В целом, у 42 (42,8%) и 51 (29,14%) пациентов в группах ф-ОАГШ и с-ОАГШ соответственно наблюдались как ранние, так и поздние симптомы демпинг-синдрома (P = 0,01) (таблица 5).

Распределение демпинг синдрома по степеням тяжести проявлений показана в таблице 6.

Таблица 6 - Распределение по тяжести демпинг-синдрома

Показатель	ф-ОАГШ n=98	с-ОАГШ n=175
Первая степень	94 (95,9%)	153 (87,4%)
Вторая степень	4 (4,08%)	29 (16,57%)
Третья степень	0 (0%)	3 (1,71)

Как видно по таблице, в обеих группах преобладала первая степень демпинг синдрома, но случаев со второй степенью было больше в группе со стандартным выполнением ОАГШ 29 (16,57%) случаев против 4 (4,08%) во второй группе с применением ФундоРинг. В доказательно превосходства метода ФундоРинг указывает отсутствие случаев демпинг синдрома третьей степени в данной группе. Важно отметить, что случаев с демпинг-синдромом IV степени мы не наблюдали ни в одной группе.

Результаты рентгенологической оценки пищевода, малого желудочка и тонкой кишки

Данные по результатам серий рентген снимков, сделанных во время рентгенологического наблюдения указаны в таблице 7.

Таблица 7 - Рентгенологические данные выборки из двух сравниваемых групп

Показатель	ф-ОАГШ n=125	с-ОАГШ n=125
Объём опорожнения малого желудочка в течении 1 минуты (порция)	1/3	1/2
Полная эвакуация бария из малого желудочка (в минутах)	20-30	15
Время прохождения тонкого кишечника контрастным веществом (часы)	5-6	4-5

Как видно из таблицы 7, объём «провала контраста» при опорожнении малого желудочка в тонкую кишку в течении 1 минуты в первой группе (ф-ОАГШ) менее значительный 1/3 порции против 1/2 порции во второй группе (с-ОАГШ).

Послеоперационное ведение и контроль демпинг-синдрома

Для контроля и снижения вероятности развития симптомов демпинг-синдрома пациенту было рекомендовано употреблять меньше пищи и чаще. Продукты, вызывающие симптомы демпинг-синдрома, были запрещены. Не рекомендовалось употребление высококалорийной пищи с высоким содержанием углеводов. Рекомендовалось употребление пищи с высоким содержанием клетчатки и белка. Не рекомендовалось употребление продуктов с быстроусвояемыми углеводами и молока. Пациентам также было рекомендовано избегать употребления воды в течение 30 минут после еды, чтобы избежать ускорения прохождения содержимого по желудочно-кишечному тракту.

Если изменение диеты и образа жизни не давало эффекта, рекомендовались препараты, повышающие вязкость, или акарбоза. При неэффективности предыдущего этапа лечения был рекомендован октреатид [16]. 8 пациентам в группе с-ОАГШ мы рекомендовали препарат Оземпик, который эффективно купировал проявления симптомов демпинг-синдрома. Препарат Оземпик замедлял опорожнение желудка и, снижая постпрандиальную гипергликемию, стимулировал

секрецию инсулина, снижая нагрузку на β-клетки и усвоение глюкозы кишечником. Ни в одной из групп мы не использовали эндоскопические и хирургические методы лечения демпинг-синдрома после ОАГШ через 1 год после операции. Это обусловлено высокой эффективностью неинвазивных методов в обеих группах. Для наших пациентов с демпинг-синдромом в обеих группах диетотерапия и медикаментозная терапия были достаточными.

4. Обсуждение

Ожирение — глобальная проблема, которая не обошла стороной и Центральную Азию [17]. Лапароскопическое одноанастомозное желудочное шунтирование является оптимальным вариантом лечения для пациентов с ожирением [18]. Хотя выполнение процедуры МБХ, особенно с мальабсорбтивными эффектами, нарушает нормальную физиологию, эта «жертва» приносится, чтобы склонить чашу весов в пользу большей пользы для здоровья. Более того, мы считаем, что частота возникновения и влияние демпинг-синдрома у пациентов сильно недооценены, как показано в нашем исследовании. При положительном восприятии ранний демпинг может быть инструментом для поддержания строгой диеты; однако не было доказано, что он имеет какую-либо значимую связь со степенью потери веса. Напротив, поздний демпинг вреден и способствует общему повышению потребления калорий во время профилактики позднего демпинг-синдрома за счет сокращения интервала между приемами пищи [19].

Частота возникновения демпинг-синдрома при ОАГШ ниже, чем при ГШРу. Мы согласны с тем, что ножка ГШРу подвергается ремоделированию с течением времени после ГШРу, возможно, из-за повышенной абсорбционной способности существующих энтероцитов или привлечения дополнительных энтероцитов, участвующих в абсорбции глюкозы [20]. Но, по нашему мнению, существует еще одна причина более низкой частоты демпинг-синдрома после ОАГШ - длинный желудочный карман при ОАГШ до 18 см в отличие от длины желудочного кармана 3-5 см при ГШРу, что является основной причиной торможения скорости опорожнения желудка. Кроме того, стенка длинного желудочного кармана более устойчива к растяжению по сравнению со стенкой тонкой кишки в пищеварительной лимбе при ГШРу, которая имеет короткий желудочный карман и «гидродинамический удар» больше приходится на стенку анастомозированной тонкой кишки, чем на стенку короткого желудочного кармана. Расширение гастроеюнального анастомоза является признанным этиологическим фактором как восстановления веса, так и демпинг-синдрома [21]. Помимо малого размера гастроэнтероанастомоза, обязательным требованием является диаметр желудочного кармана-«трубки». Мы выполняем гастроэнтероанастомоз с использованием бужа 32 Fr. Таким образом, несколько факторов (специальная фундопликация, размер желудочного кармана и гастроэнтероанастомоз) объясняют причину снижения демпинг-синдрома в группе ФундоРинг. Это происходит за счет более выраженного снижения скорости эвакуации пищи из желудочного кармана и, соответственно, уменьшения осмолярного шока.

Используя большую выборку из 500 пациентов в каждой группе, мы сравнили влияние фундопликации из дна исключенного отдела желудка на частоту демпинг-синдрома. ПГТТ и уровень инсулина оценивались у всех пациентов. В частности, ПГТТ проводился в течение 3 часов с забором крови каждые полчаса до провокации и в течение 3 часов после нее. Ни один пациент не был потерян в течение 1 года наблюдения. Результаты показали, что ранний и поздний демпинг-синдром встречались значительно реже в группе ф-ОАГШ. В отличие от этого результата, оценка по шкале Сигстада и частота демпинг-синдрома после с-ОАГШ были выше и сопоставимы с результатами других исследований. [2, 3].

Наилучшие показатели в группе с ф-ОАГШ мы связывали не только с замедленной эвакуацией содержимого из желудочного кармана, но и с меньшим объемом пищи, который пациент мог съесть при увеличении ограничительного компонента при использовании метода ФундоРинг Это соответствует основной нехирургической рекомендации диетологов: пациентам с демпинг-синдромом «следует есть меньше и медленнее». Это связано с тем, что меньший объем пищи стимулирует поджелудочную железу к меньшей выработке инсулина (без высокого пика инсулина) и, соответственно, вызывает меньше гипогликемии, которая является причиной позднего демпинг-синдрома. В пользу такого объяснения можно привести пример положительного влияния сандостатина (октреотида) на лечение демпинг-синдрома.

Таким образом, низкая частота демпинг-синдрома при ф-ОАГШ по сравнению с с-ОАГШ связана со следующими факторами: 1) Наличие длинной фундопликационной манжеты с двойной калибровкой манжеты создает эффект «желудочного бандажа» из аутологичных тканей, что замедляет продвижение пищевого комка. через желудочный карман при ОАГШ. В то же время, длинная фундопликационная манжета уменьшает степень расширения желудочного кармана при ОАГШ при попадании пищи в желудок. 2) Фундопликационная манжета значительно усиливает рестриктивный компонент хирургического вмешательства. Это уменьшает количество пищи, которое может съесть пациент. 3) Согласно нашим результатам, более низкий уровень пика инсулина после ф-ОАГШ приводит к меньшему снижению уровня глюкозы через 2-3 часа после еды.

В большинстве предыдущих исследований утверждается, что демпинг часто снижает вес и положительно влияет на результаты бариатрических операций [22, 23]. Нам сложно однозначно согласиться с этим выводом этих авторов. Несмотря на более частый демпинг в группе с с-ОАГШ, наибольший эффект процедуры на снижение веса наблюдался в группе с ф-ОАГШ. Метод желудочного шунтирования ФундоРинг привел к значительно большей дельте снижения ИМТ.

Мы можем объяснить этот результат снижения веса, а также лучший антидемпинговый результат, увеличением рестриктивного компонента процедуры в группе ф-ОАГШ. Предыдущие исследования показали аналогичные лучшие результаты при использовании метода ФундоРинг для профилактики и лечения рефлюкс-эзофагита [24, 25].

Ни одному пациенту ни в одной из групп не проводилась ревизия или реверсивная операция. Поэтому ни один пациент не был исключен из анализа результатов по этой причине. Хирургическая техника, использованная в обеих группах, оказалась надежной и высокоэффективной.

Мы не наблюдали случаев несостоятельности степлера, тромбоэмболических осложнений или других неотложных хирургических осложнений.

Мы ожидали развития дисфагии в группе ф-ОАГШ в связи с использованием циркулярной фундопликационной манжеты, но в результате исследования мы не наблюдали существенной разницы в качестве глотания, и пациенты в группе ф-ОАГШ не сообщали о дисфагии. Длинная фундопликационная манжета в группе ф-ОАГШ после калибровки не сдавливает пищевод и верхнюю часть желудочного кармана, поскольку дно исключенной части желудка хорошо мобилизовано при пересечении селезеночно-желудочной связки, а при методе ФундоРинг не наблюдается скручиваний и деформаций, как это наблюдается при обычной круговой фундопликационной манжете при изолированном хирургическом лечении гастроэзофагеальной рефлюксной болезни.

Полученные нами результаты по данным контрастного рентгенологического исследования, определения уровня инсулина и результатов глюкозотолератного теста являются научной основой для рекомендации более широкого клинического применения разработанного нами метода ФундоРинг.

5. Выводы

Модифицированная фундопликация отключённого желудка (ФундоРингОАГШ), значительно эффективнее снижала ранние и поздние симптомы демпинг-синдрома по сравнению со стандартной ОАГШ в течение 1 года.

ФундоРинг, препятствуя растяжению желудочного кармана, обеспечивает пищевую регуляцию продукции инсулина без высокой концентрации (подобно механизму октреотида), соответственно, реже вызывает гипогликемию. Наличие длинной фундопликационной манжеты с двойной калибровкой манжеты (ФундоРинг) создает эффект «желудочного бандажа» из аутологичных тканей и смягчает (уменьшает) «гидродинамический шок» при поступлении пищи в желудок из пищевода. Таким образом, замедляется продвижение пищевого комка по желудочному карману (по механизму действия агониста рецептора глюкагоноподобного пептида-1 (ГПП-1)) при ОАГШ и, таким образом, наблюдается менее резкий подъем сахара и более медленное и продолжительное его снижение во времени по сравнению с желудочным шунтированием без ФундоРинга.

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Контрасты рентгенографиялық зерттеу деректері, инсулин деңгейін анықтау және глюкозаға төзімділік сынағы нәтижелері бойынша FundoRing әдісін қолдану арқылы асқазанды айналып өтуден кейінгі демпингтік синдромның жиілігін салыстыру

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Түйіндеме

Кіріспе. Бір анастомозды асқазанды айналып өту (SAGB) семіздікті емдеудің тиімді әдісі болып табылады. Дегенмен, операциядан кейінгі демпингтік синдромның (ДС) жиілігі өзекті мәселе болып қала береді. DS жиілігін азайту тәсілі ретінде ажыратылған асқазанды пайдаланып фундопликацияны қоса, FundoRing модификацияланған әдіс ұсынылады.

Әдістері. 1000 пациент (FundoRing OAGSh (f-OAGSh) тобындағы 500 және стандартты OAGSh (s-OAGSh) тобындағы 500) пациенттердің қатысуымен бір орталықты, рандомизацияланған бақыланатын зерттеу жүргізілді. ДС жиілігі глюкозаға төзімділік сынағы, инсулин деңгейі және асқазан сөмкесін босату жылдамдығының рентгендік белгілері бойынша бағаланды.

Нәтижелер. Бір жылдан кейін демпингтік синдромның жиілігі f-OAGSh тобында 19,6% және s-OAGSh тобында 35% құрады (p=0,001). DS және ауыр дәрежелердің кеш көріністері f-OAGSh тобында айтарлықтай аз болды. Фундопликациясы бар науқастарда глюкоза мен инсулин деңгейінің біркелкі жоғарылауы мен төмендеуі байқалды. Рентгенологиялық зерттеуде f-OAGSh тобындағы асқазан қалтасының баяу босатылуы және барийдің аш ішек арқылы ұзағырақ өтуі анықталды.

Қорытынды. FundoRingOAGSh дәстүрлі OAGSh-пен салыстырғанда демпингтік синдромның жиілігі мен ауырлығын сенімді түрде төмендетеді және кеңірек клиникалық қолдану үшін ұсынылуы мүмкін.

Түйінді сөздер: демпингтік синдром, FundoRing, бір анастомозды асқазанды айналып өту, бариатриялық хирургия, глюкозаға төзімділік сынағы, инсулин, контраст рентгенографиясы, семіздік, фундопликация.

Comparison of dumping syndrome incidence after gastric bypass using the fundoring technique based on contrast radiography, insulin levels, and oral glucose tolerance test results

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Abstract

Introduction. Single-anastomotic gastric bypass (SAGB) is an effective treatment for obesity. However, the incidence of postoperative dumping syndrome (DS) remains a pressing issue. A modified FundoRing technique, including fundoplication using a divided stomach, is proposed as a way to reduce the incidence of DS.

Methods. A single-center, randomized, controlled trial was conducted in 1000 patients (500 in the FundoRing OAGSh (f-OAGSh) group and 500 in the standard OAGSh (s-OAGSh) group). The incidence of DS was assessed by glucose tolerance testing, insulin levels, and radiographic signs of gastric emptying rate.

Results. After one year, the incidence of dumping syndrome was 19.6% in the f-OAGSh group and 35% in the s-OAGSh group (p=0.001). Late manifestations of DS and severe degrees were significantly less in the f-OAGSh group. Patients with fundoplication showed a uniform increase and decrease in glucose and insulin levels. Radiological examination revealed slower gastric emptying and longer transit of barium through the small intestine in the f-OAGSh group.

Conclusion. FundoRingOAGSh reliably reduces the incidence and severity of dumping syndrome compared with traditional OAGSh and can be recommended for wider clinical use.

Keywords: dumping syndrome, FundoRing, single-anastomotic gastric bypass, bariatric surgery, glucose tolerance test, insulin, contrast radiography, obesity, fundoplication.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj006

Prevalence of ophthalmopathology among miners with occupational bronchopulmonary diseases

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Received: 15.02.2025
Accepted: 23.09.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj006.

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Abstract

Dust-related lung diseases, including pneumoconiosis, chronic obstructive pulmonary disease (COPD), and silicosis, continue to be a major cause of disability among miners. The harmful effects of coal and silica dust are not limited to the respiratory system but also negatively impact the visual system. Current scientific data indicate an increase in ophthalmological disorders such as dry eye syndrome, reduced corneal sensitivity, and retinal pathologies. However, this issue remains insufficiently studied.

Ophthalmological diseases in miners with dust-related lung conditions represent a significant but underexplored issue. There is a lack of epidemiological data on the prevalence of ophthalmopathologies among miners in Kazakhstan, highlighting the need to adapt international experience in early diagnosis and prevention of ophthalmological complications.

Key words: miners, occupational diseases, coal dust, ophthalmopathology, dry eye syndrome (DED).

1. Introduction

At present, dust-related lung diseases (DRLDs) are considered one of the main predictors of premature loss of working capacity among young individuals. Dust-induced pulmonary pathologies (pneumoconiosis, chronic obstructive pulmonary disease [COPD], and silicosis) remain a serious global public health issue [1]. According to the Global Burden of Disease (GBD) 2016 study, more than 76 million disability-adjusted life years (DALYs) were attributed to occupational risks [2].

Particular concern arises regarding DRLDs among workers in the coal, metallurgical, and construction industries, where dust concentration is particularly high [3]. Prolonged exposure to coal dust adversely affects not only the respiratory system but also induces systemic dysfunctions in the body, including impairments of the visual apparatus [4]. According to GBD 2019 data, the number of years of life lost due to blindness and visual impairment reached 22.6 million DALYs, with cataract (29.6%), refractive errors (29.1%), near vision impairment (21.7%), vision loss (13.7%), glaucoma (3.3%), and age-related macular degeneration (2.5%) being the leading causes [5]. As a result, both quality of life and work capacity of miners deteriorate significantly [6].

Despite the accelerating global transition to "green" energy, the coal industry remains one of the pillars of the world's energy supply [7]. The hazardous working conditions in coal mines pose potential risks for pathological processes across various organs and systems, including the visual system, contributing to the growing incidence of ophthalmopathologies among miners [8].

There are several primary methods of coal extraction (open-pit, shaft, and mountain mining), depending on the depth of coal seams, geological conditions, and economic feasibility. Workers mining coal at depths greater than 600 meters encounter extremely dust-laden environments, with coal dust concentrations exceeding 3000 mg/m^3, far surpassing permissible thresholds (4 mg/m^3 for total dust according to PC-TWA methodology) [9,10].

Recent studies convincingly demonstrate that under hypoxic conditions excessive production of reactive oxygen and nitrogen species (ROS/RNS) occurs, leading to oxidative stress — the main factor contributing to the development of ophthalmological pathologies in miners. An imbalance between free radicals and protective antioxidant mechanisms results in degradation of cellular membranes and induction of apoptosis in corneal epithelium [11–13].

Inhalation of coal dust at high concentrations causes substantial harm to miners' health, manifesting as headaches, irritation of the throat, nose, and eyes, drowsiness, dyspnea, and nausea [14]. Frequently, coal miners neglect safety protocols and do not use personal protective equipment (PPE) such as protective goggles, helmets, and respirators. Consequently, miners' eyes in underground mines are directly exposed to high dust concentrations [15].

Limited illumination in mining environments further impairs visual functions, manifesting as binocular vision disorders and reduced visuomotor coordination [16]. Moreover, workers in the coal industry often demonstrate impaired tear film function and development of dry eye disease (DED) [17].

Thus, the primary factors increasing the risk of DED among underground coal miners include: prolonged (more than 10 years) work in adverse underground conditions, inhalation of coal dust enriched with crystalline silicon dioxide (SiO_2), and recurrent superficial ocular (corneal and conjunctival) trauma [18].

All of the above-mentioned factors contribute to disability and loss of work capacity among miners, and despite preventive efforts, they continue to affect a significant proportion of the mining workforce each year [19].

Nevertheless, a detailed analysis of contemporary scientific publications demonstrates that ophthalmological aspects of DRLDs remain insufficiently explored, despite existing evidence of the influence of dust-related factors on ocular surface health [20].

Considering the fragmented nature of current knowledge regarding ophthalmological complications among coal industry workers, the objective of this review is to identify and comparatively analyze the nosological spectrum and prevalence of ocular pathologies in individuals with occupational dust-related bronchopulmonary diseases.

2. Materials and Methods

Methodological approach

This review was conducted in accordance with the five-stage methodological framework originally described by Arksey and O'Malley, which includes the following steps: identification of the research question; identification of relevant studies; study selection; charting of data; and collating, summarizing, and reporting results [21]. These core stages were refined using the methodological guidance provided by the Joanna Briggs Institute (JBI), which offers additional clarity regarding protocol development, eligibility criteria, and strategies for data presentation [22].

Scope of studies

The analysis covered publications from 2015 to 2025 without regional restrictions. Primary attention was given to underground coal miners; however, several studies also considered workers in metallurgy and related industries.

Search strategy

The literature search was conducted in electronic databases including PubMed, Scopus, and Web of Science. Additionally, relevant materials not indexed in leading scientific databases but containing valuable information were included.

Data extraction

Data were systematized in a standardized extraction form created in Microsoft Excel. The form included fields for study characteristics such as country and sample size, nosological classification, prevalence, as well as keywords and key findings.

Inclusion criteria

Publications from 2015–2025:

1. studies addressing ophthalmopathologies in miners and patients with dust-related bronchopulmonary diseases;
2. exposure: coal and/or silica dust;
3. types of publications: systematic and descriptive reviews, clinical and observational studies;
4. outcomes: ophthalmological nosologies with reported prevalence or frequency.

Exclusion criteria

1. lack of relevance to occupational dust exposure (e.g., general ophthalmological or respiratory diseases unrelated to industrial dust);
2. Absence of empirical data;
3. Publications outside the 2015–2025 timeframe;
4. Articles without an English-language or accessible full-text version.

3. Results and discussion

The review of findings was presented in a descriptive format. Due to heterogeneity of study designs, outcomes, and diagnostic methods, meta-analysis was not performed. Instead, data were grouped into thematic clusters covering: nosological forms of ophthalmopathologies among miners, prevalence in different countries, risk factors and pathogenesis, diagnostic methods, and socio-economic implications.

Study selection

The study selection process involved a comprehensive search of major databases (PubMed, Scopus, Web of Science) and assessment of additional

relevant materials. Initially, 108 records were identified. After duplicate removal and screening of titles and abstracts, 54 articles were selected, of which 47 were excluded as irrelevant. The final synthesis included 7 full-text studies: 5 original clinical investigations, 1 cohort study, and 1 descriptive study. Research conducted across different countries consistently confirmed the identified trends.

Comparative analysis

The analysis demonstrated a widespread occurrence of ophthalmological disorders among miners. Literature sources indicated that dry eye disease (DED) is the most common condition among miners, reported in five out of six countries. Other ophthalmological disorders exhibited regional specificity: corneal microtrauma was characteristic of Ukraine, conjunctivitis and blepharitis of Russia, pterygium and keratitis of Pakistan, binocular vision disorders of India, and retinal changes of China.

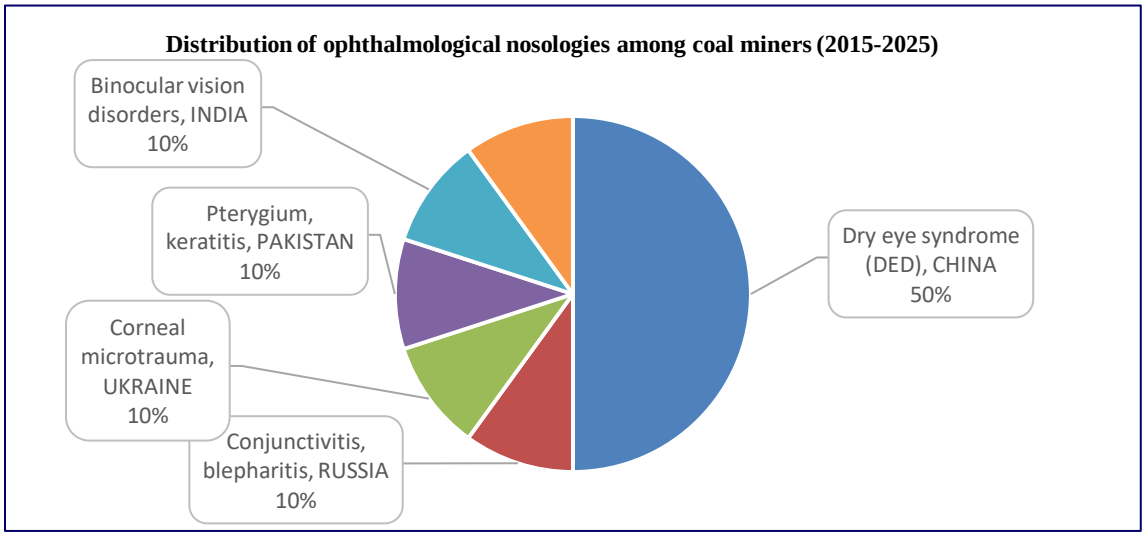

Figure 1 - Nosology and prevalence of ocular diseases among miners in different countries (2015–2025)

According to a study conducted by the Chinese Institute of Ophthalmology in 2023, the prevalence of dry eye disease (DED) among miners was 35–45%, which significantly exceeded the rates observed in the control group (OR = 1.26; 95% CI: 1.14–1.30; $p < 0.001$) [23]. Moreover, Chinese miners demonstrated thinning of the retinal nerve fiber layer (RNFL) and vascular alterations, which were statistically different from the control population [24].

A study conducted in the Kuznetsk Coal Basin (Kuzbass) in the Russia, one of the largest coal deposits in the world, revealed a high prevalence of conjunctivitis, blepharitis, and DED in 30–40% of cases among miners with more than 10 years of work experience [25].

According to research by Bulent Ecevit University in Turkey, miners with dust-related lung diseases, particularly pneumoconiosis, demonstrated DED and tear film instability in 50% of cases [26].

A study conducted in 2024 by Liaquat University of Medical and Health Sciences in collaboration with the People's Nursing School of Pakistan identified a high frequency of pterygium, keratitis, and DED (50–60%) among miners with more than 6 years of work experience. The authors emphasized the unfavorable working conditions, including extended shifts, lack of adequate eye protection, and insufficient medical monitoring [27].

Publications from the Department of Ophthalmology, Bangalore Medical College, India [28], mainly focused on functional vision disorders such as binocular vision and visuomotor coordination. The authors associated these changes not only with dust

exposure but also with insufficient lighting in mines, highlighting the role of additional occupational factors.

Ukrainian data published by Ivano-Frankivsk Medical University [29] indicated a high prevalence of dry eye disease (40%) and corneal microtrauma (20–25%) among miners working in dusty conditions for more than 10 years.

The findings presented in Table 1 clearly demonstrate that dry eye disease (DED) is the predominant ophthalmological pathology among miners in most of the studied countries.

Table 1 - Distribution of ophthalmological nosologies among miners according to the literature (2015–2025). Dry eye disease (DED) was the most frequently reported disorder, documented in five out of six countries

Country, year	Type of mines	n - miners	Nosology	Method	Frequency
China (Huainan), 2023	Underground coal	3749	Dry eye syndrome (DED)	OSDI questionnaire	35-45%
China (Kailuan), 2022	Underground coal	4004	RNFL thinning and vascular changes, OCT and vascular analysis	OCT, vascular analysis	Statistically significant compared with controls
Russia (Kuzbass), 2019	Underground coal	2217	Conjunctivitis, blepharitis, DED	Descriptive statistics	30–40% among workers with >10 years of experience
Turkey, 2017	Underground coal	46	DED, tear film instability (>50%)	Schirmer test, BUT.	>50 %
India, 2024	Underground coal	64	Binocular vision disorders (20–30%)	Prospective cross-sectional study	20-30%
Pakistan, 2021	Underground coal	317	Pterygium, DED, keratitis	Descriptive cross-sectional study, diagnostic standards for NSBVD	50–60% with >6 years of experience
Ukraine, 2018	Underground coal	250	DED (40%), corneal microtrauma	clinical examination, Schirmer test, BUT	DED - 40%, microtrauma 20-25%

The analysis highlighted regional features of ophthalmological disorders affecting both the anterior (conjunctiva, cornea) and posterior (retina) segments of the eye. These findings confirm that chronic exposure to coal and silica dust contributes to a wide spectrum of ophthalmological complications, while scientific interest in different countries has been directed toward specific clinical manifestations.

4. Discussion

Several factors contribute to the etiopathogenesis of ophthalmological diseases, with oxidative stress (OS) playing a central role in various forms of retinopathy. In particular, Nebbioso et al. [30] considered OS a key pathogenic mechanism in DED, which is supported by the studies of Pflugfelder, de Paiva (2017), and Dammak et al. [31,32]. Similarly, Malaviya and colleagues [33] identified associations between chronic NADPH oxidase activation, mitochondrial dysfunction, and lipid peroxidation in the retina. The findings of Chen et al. [34], demonstrating the protective effect of fullerenol in reducing corneal damage under UV exposure, further confirm the role of reactive oxygen species (ROS) as critical damaging agents.

Chronic hypoxia, a characteristic feature of the pathogenesis of pneumoconiosis and COPD in miners, also represents a significant factor in the development of ophthalmological complications. Hypoxic conditions lead to impaired microcirculation and ischemic changes in ocular tissues. Research conducted in China and Russia has demonstrated statistically significant differences in RNFL thickness and vascular status among miners with dust-related lung diseases compared with control groups, confirming the role of chronic hypoxia in the development of retinopathies.

A third important mechanism is systemic inflammation triggered by ROS. It has been shown that OS activates pro-inflammatory cytokines (IL-6, TNF-α), which intensify inflammatory changes in the tear film and contribute to retinal damage. The study of inflammatory biomarkers is of primary importance. According to Ozcan D. Ozarslan et al. [35], elevated levels of IL-6 and IL-10 were recorded in patients with DED, indicating the involvement of systemic inflammatory responses in the pathogenesis of the disease. Comparable findings were presented by H.H. Wang and colleagues [36], who identified IL-6 as a key indicator of tear film dysfunction. Review articles by K. Narendra and D. Huang [37] further emphasized the universality of these cytokines in assessing the degree of inflammatory processes in ophthalmopathologies associated with aerosol particle exposure.

Similar mechanisms were described by Valle et al. [38] in studies of diabetic retinopathy, highlighting the universality of inflammatory processes in ocular pathologies and allowing extrapolation to the miner population exposed to chronic dust exposure. These conclusions are consistent with the work of Kowluru and Malaviya [39], who demonstrated that mitochondrial dysfunction and depletion of antioxidant systems are major drivers of chronic ocular inflammation.

Currently, MMP-7 and SP-D are recognized biomarkers of fibrosis and inflammation. These markers, known for their roles in interstitial lung diseases and tissue remodeling processes, allow assessment of the degree of damage and prediction of disease progression. Studies have shown that MMP-7 is an independent predictor of progression and mortality in pulmonary fibrosis, while the combination of SP-D and MMP-7 aids in the differential diagnosis of idiopathic pulmonary fibrosis [40,41]. In the ophthalmological context, these mechanisms are of particular importance, since chronic inflammation and fibrosis can lead to tear film and ocular surface damage. Moreover, SP-D exerts a protective effect on the ocular surface, reducing infection risk and supporting epithelial stability in DED [42]. Therefore, elevated levels of these biomarkers may contribute to the development of ocular complications in miners.

Taken together, the available evidence confirms that three synergistic pathogenetic processes — oxidative stress, hypoxia, and systemic inflammation — form the etiological basis of ophthalmological pathologies among coal industry workers. Clinically, these manifest as dry eye disease, corneal damage, corneal hypoesthesia, as

well as vascular and neurodegenerative changes in the retina (Figure 2).

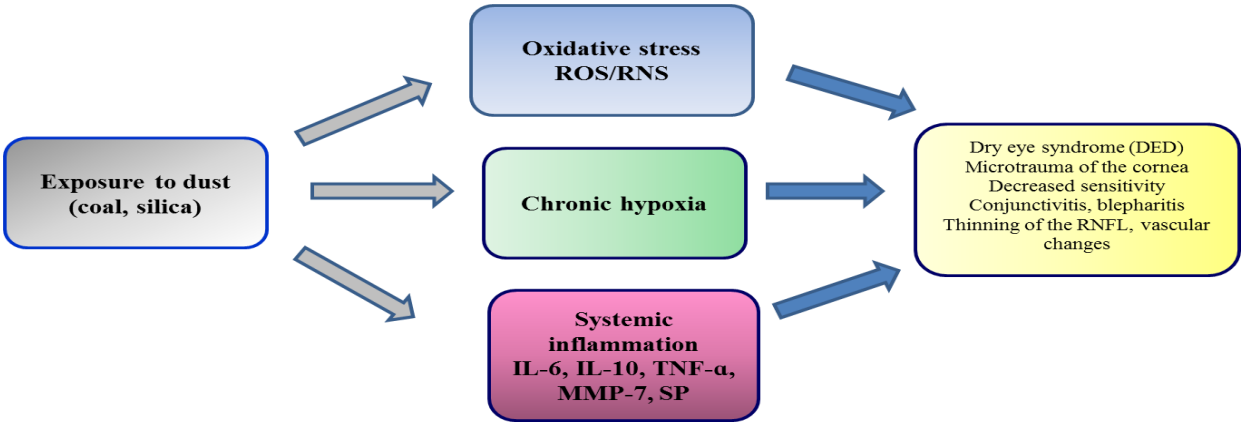

Figure 2 - Pathogenesis of ocular complications in miners. Exposure to coal and silica dust induces oxidative stress, hypoxia, and systemic inflammation. These processes lead to damage of the anterior segment of the eye (dryness, corneal microtrauma, conjunctivitis) and the posterior segment (RNFL thinning, vascular changes)

The prevalence of ophthalmological diseases among miners carries profound social and economic implications. Visual impairment directly reduces miners' work capacity, increases occupational injury risk, and often necessitates early termination of employment. This, in turn, imposes additional burdens on healthcare and social security systems, as well as on compensation programs provided by employers. According to Petsonk et al. [43], dust-related lung diseases exert significant socio-economic impacts, including increased healthcare costs and reduced labor productivity among miners.

For coal-producing regions, where the coal industry plays a pivotal role in the economy and where large populations of workers are exposed to dust, vision loss or deterioration among miners has especially severe social and economic consequences. Therefore, ophthalmopathologies in miners should be regarded not only as a medical issue but also as a factor generating substantial additional social and economic burdens for industrial regions.

5. Conclusions

The analysis of collected scientific evidence demonstrated that, despite the general trend of high prevalence of ocular pathologies among coal industry workers, the research focus varies considerably across countries. These differences are determined both by methodological approaches and by specific working conditions in different regions.

In the context of Kazakhstan, where dust-related lung diseases are widespread among coal industry workers, there is a notable lack of data on the prevalence of ophthalmological complications in available sources. It is assumed that even if relevant studies were conducted, their findings were either not published in international databases or remain inaccessible for analysis. This situation creates a critical gap in understanding the impact of occupational dust factors on the visual system and highlights the need for national-level research.

Despite the variety of reported conditions, all studies confirm that the eyes of miners represent a key target organ affected by occupational risk factors. The

variability in findings across countries is more likely related to differences in research emphasis and workplace conditions rather than to the specific characteristics of the pathologies themselves.

This review systematized domestic and international evidence regarding the types and prevalence of ophthalmological diseases among miners exposed to coal and silica dust:

– Dry eye disease (DED) is the most frequently reported ocular manifestation in miners exposed to long-term coal dust, with prevalence ranging from 30–45% in published studies from China, Ukraine, Russia, and Turkey. This allows it to be considered a key indicator of occupational dust-related ocular impact.

– In addition to DED, miners are affected by various ocular pathologies, including inflammatory disorders of the conjunctiva and eyelids (conjunctivitis, blepharitis), corneal damage (microtrauma, pterygium, keratitis), binocular vision disorders, as well as retinal changes (RNFL thinning, vascular abnormalities). These findings reflect the complex and multifactorial impact of dust exposure on both the anterior and posterior segments of the eye.

– The results of this review emphasize the importance of incorporating ophthalmological complications into the broader context of occupational diseases. They can serve as a foundation for developing rehabilitation programs aimed at the prevention and protection of miners' vision.

Funding information. This article was prepared within the framework of program-targeted funding for scientific and/or scientific-technical projects for 2024–2026 by the Ministry of Science and Higher Education of the Republic of Kazakhstan (IRN BR27199517) «A comprehensive approach to medical prevention and rehabilitation of occupational dust-related bronchopulmonary diseases».

Conflict of interest. The authors declare no conflicts of interest requiring disclosure in this article.

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Бронхөөкпе жүйесінің кәсіптік аурулары бар кеншілерде офтальмопатологияның таралуы

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Түйіндеме

Өкпенің шаңды аурулары, соның ішінде пневмокониоз, өкпенің созылмалы обструктивті ауруы (ӨСОА) және силикоз, шахтерлер арасында еңбекке жарамдылықты жоғалтудың негізгі себептерінің бірі болып қалуда. Сонымен қатар, көмір мен кремний шаңының зиянды әсері тек тыныс алу жүйесімен шектелмей, көру ағзаларына да кері әсерін тигізеді. Қазіргі ғылыми деректер көз ауруларының, мысалы, құрғақ көз синдромы,

қасаң қабықтың сезімталдығының төмендеуі және тор қабық патологияларының жиілеуін көрсетеді, алайда бұл мәселе әлі де жеткіліксіз зерттелген.

Шаңды өкпе аурулары бар шахтерлердегі офтальмологиялық аурулар — маңызды, бірақ жеткіліксіз зерттелген мәселе. Қазақстанда шахтерлер арасында офтальмопатологиялардың таралуы туралы эпидемиологиялық деректер жоқ, бұл көз ауруларының ерте диагностикасы мен алдын алуда халықаралық тәжірибені бейімдеудің қажеттілігін көрсетеді.

Түйін сөздер: шахтерлер, кәсіби аурулар, көмір шаңы, офтальмопатология, құрғақ көз синдромы (DED).

Распространённость офтальмопатологии у шахтеров с профессиональными заболеваниями бронхопульмональной системы

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Резюме

Пылевые заболевания легких, включая пневмокониоз, хроническая обструктивная болезнь легких и силикоз, продолжают оставаться основной причиной потери трудоспособности среди шахтеров. При этом вредное воздействие угольной и кремниевой пыли не ограничивается дыхательной системой, оказывая негативное влияние и на органы зрения. Современные научные данные свидетельствуют о росте офтальмологических нарушений, таких как синдром сухого глаза, снижение чувствительности роговицы и патологии сетчатки, однако эта проблема изучена недостаточно.

Офтальмологические заболевания у шахтёров с пылевыми заболеваниями лёгких представляют собой значимую, но недостаточно исследованную проблему. В Казахстане отсутствуют эпидемиологические данные о распространённости офтальмопатологий у шахтёров, что подчёркивает необходимость адаптации международного опыта ранней диагностики и профилактики офтальмологических осложнений.

Ключевые слова: шахтёры, профессиональные заболевания, угольная пыль, офтальмопатология, синдром сухого глаза (DED).

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj007

Modern Aspects of the Metaphylaxis Management for Recurrent Urolithiasis

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Received: 11.02.2025
Accepted: 21.06.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj007.

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Abstract

Urolithiasis, or kidney stone disease, is a common condition characterized by the formation of stones in the kidneys and urinary tract. The recurrence rate is about 50% within the first 5–10 years after the initial episode, making recurrence prevention a key medical goal. Metaphylaxis, a comprehensive approach to preventing stone recurrence, includes lifestyle modifications, dietary recommendations, pharmacotherapy, and regular patient monitoring. This approach allows consideration of individual metabolic, genetic, and environmental factors contributing to stone formation.

This review aims to summarize the literature on the primary methods used in the metaphylaxis of recurrent urolithiasis in adults.

A systematic review was conducted using databases such as PubMed, Embase, Cochrane Library, Web of Science, and Google Scholar. Studies published between 2010-2024 in English, Russian, and Kazakh were included. Clinical studies, RCTs, systematic reviews, and meta-analyses were selected. Citation tracking was also used to identify additional relevant sources.

The primary strategies for metaphylaxis in urolithiasis include increased fluid intake, dietary adjustments, and pharmacological treatment. Consuming at least 2.5 liters of water per day lowers the risk of stone formation. Pharmacotherapy with thiazides, citrates, and allopurinol has proven effective in reducing recurrence rates. Advanced technologies assist in patient monitoring and provide more precise treatment.

Metaphylaxis for urolithiasis represents a comprehensive approach based on lifestyle modifications, pharmacotherapy, and the use of new technologies. Personalized strategies have demonstrated effectiveness. Technological advancements promise further improvements in treatment outcomes and enhance patient adherence to preventive measures.

Key words: urolithiasis, kidney stones, recurrence, metaphylaxis, dietary therapy, pharmacotherapy, lifestyle changes.

1. Introduction

Urolithiasis, commonly referred to as kidney stones, affects approximately 10% of population globally and is associated with a high recurrence rate, with approximately 50% of patients experiencing stone formation again within 5-10 years of the initial episode [1,2]. Men are more likely to develop kidney stones; however, women often face more severe complications, such as a higher risk of chronic kidney disease (CKD) [2]. Recurrent urolithiasis presents not only a medical challenge but also a socioeconomic burden. Due to their acute presentation, kidney stones result in a significant number of emergency department visits and hospitalizations. Worldwide, the socioeconomic burden of recurrent urolithiasis is substantial, with healthcare costs exceeding billions annually. In the United States alone, the direct cost of kidney stones treatment was estimated at $3.79 billion in 2007, with projections indicating an annual increase of $1.24 billion by 2030 [3]. Frequent medical consultations, repeated surgical interventions, and a decline in patients' quality of life contribute to substantial healthcare costs [3,4,5]. Unlike many chronic conditions, kidney stones predominantly affect working-age individuals between 20 and 60 years old. This exacerbates economic costs, as the condition also results in productivity losses due to missed workdays and decreased efficiency in the workforce [3].

Despite advancements in treatment, metaphylaxis—the prevention of recurrence—remains a critical yet underexplored area. Current strategies, including lifestyle modification, dietary interventions, pharmacotherapy, and regular health monitoring, are often debated. For instance, the efficacy of pharmacological treatments like thiazides and allopurinol is questioned due to potential side effects and inconsistent outcomes [6]. Similarly, the role of dietary modifications, such as calcium restriction, remains controversial, as excessive restriction may actually increase stone formation risk [7]. These controversies highlight the need for a more personalized and evidence-based approach. This study aims to address these gaps by exploring innovative and tailored metaphylaxis strategies, considering metabolic, environmental, and genetic factors contributing to kidney stone formation.

2. Methods

To ensure a comprehensive and systematic review of the literature on metaphylaxis for recurrent urolithiasis, several academic databases were searched, including PubMed, Embase, the Cochrane Library, Web of Science, and Google Scholar. The search focused on articles published between 2010-2024, with no restrictions on geographical region but limited to studies published in English, Russian and Kazakh languages. The search terms included combinations of "urolithiasis", "kidney stones", "recurrent", "recurrence", "metaphylaxis", "prevention", "diet therapy", "pharmacotherapy", and "lifestyle modifications" among others. Boolean operators (AND, OR) were used to refine the search and capture studies covering various aspects of metaphylaxis, including dietary interventions, pharmacological approaches, and monitoring strategies.

As illustrated in Figure 1, a total of 1,254 studies were initially identified based on titles and abstracts. After removing duplicates, 1,041 records remained, of which 568 were excluded during title screening. The remaining 473 articles underwent abstract screening, resulting in the exclusion of an additional 295 studies. Consequently, 178 full-text articles were assessed for eligibility. Following the application of strict inclusion and exclusion criteria, 34 studies were ultimately included in the final analysis. The inclusion criteria were clinical studies, randomized controlled trials (RCTs), systematic reviews, meta-analyses, and large prospective studies, focusing on metaphylaxis strategies. Exclusion criteria included studies focused solely on surgical interventions for kidney stones and those not addressing recurrence prevention publications. Studies were also excluded if they consisted of case reports or small case series, as these provide limited generalizability for recurrence prevention. Additionally, articles were excluded if they lacked specific data on recurrence outcomes or were non-peer-reviewed, such as conference abstracts and opinion pieces, to maintain the rigor and relevance of the review. Citation tracking was also employed to identify additional relevant sources through forward and backward searching of key papers.

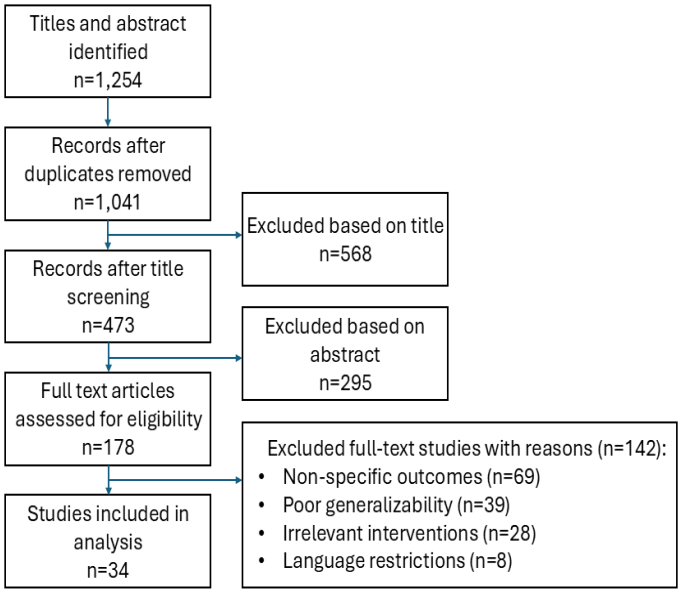

Figure 1 - Critical review selection flowchart

3. Results and discussion

Metaphylaxis for urolithiasis involves various strategies aimed at preventing the recurrence of kidney stones. The main strategies include:

Dietary Modifications

Increased *fluid intake* is one of the most basic strategies to reduce stone formation by diluting urine. Adults should aim to consume at least 2.5 to 3 liters of fluid per day [8]. Adequate fluid intake is essential to produce a urine volume of at least 2.5 liters per day, which helps dilute the concentration of stone-forming solutes such as calcium, oxalate, and uric acid [9]. Although there is no definitive threshold for urine volume and the risk of kidney stones recurrence, as the relationship is continuous and may not be linear. Increased urine volume reduces the supersaturation of these solutes, thereby decreasing the risk of crystal formation and stone growth [10]. Studies have shown that higher fluid intake is associated with a lower risk of stone recurrence [8,11]. While water is the most recommended fluid, other beverages can also contribute to fluid intake. Alkalizing beverages, such as citrus juices, can be particularly beneficial as they increase urinary citrate levels, which inhibit stone formation [12]. A recent systematic review has demonstrated that citrus-based products, such as lemonade, orange juice, and grapefruit juice, can increase urinary citrate levels and urine pH. The data indicates that citrus-based products raised urine pH (mean difference, 0.16; 95% confidence interval [CI] 0.01-0.32) and urinary citrate (mean difference 124.49; 95% CI 80.24-168.74) more significantly than the control treatment [13]. However, not all beverages are equally effective in lowering the risk of kidney stones. Conversely, consumption of sugar-sweetened sodas and punches is linked to an increased risk of kidney stone formation. One study depicted that drinking sugar-sweetened cola regularly increases the risk of developing kidney stones by 23% compared to those in the rarely drink [14].

Dietary adjustments may vary based on the type of stone and may include reducing or increasing the consumption of specific types of foods.

For *calcium oxalate stones*, it is recommended to maintain a balanced calcium intake of 1,000 to 1,200 mg daily from dietary sources, such as dairy products and leafy greens [15,16]. Additionally, limiting the intake of high-oxalate foods like spinach, nuts, chocolate, and tea can help reduce oxalate absorption [17,18]. For individuals with calcium kidney stones, it is crucial to limit salt intake to reduce the risk of stone formation. The excess of sodium reduces the kidney's ability to reabsorb calcium, resulting in higher calcium levels in the urine [19]. Current guidelines recommend consuming less than 2,300 mg of sodium per day, with a further reduction to 1,500 mg per day for those with a history of kidney stones [10]. High-sodium foods, such as processed and packaged items, should be avoided, and it is important to read nutrition labels to choose lower-sodium options. Cooking at home can also help control the amount of salt added to meals [20,21].

For *calcium phosphate stones*, maintaining balanced calcium intake from dietary sources is crucial, while avoiding excessive calcium supplementation, as excess calcium can increase the risk of phosphate stone formation [15,16]. Epidemiological evidence from a large study shows that the prevalence of stones progressively increases as dietary calcium intake falls below approximately 720 mg/day [22]. Like previous recommendations, reducing sodium intake to below 2,300 mg per day is advised, as high sodium consumption leads to elevated urinary calcium excretion [15,16]. Limiting animal protein intake is found to be beneficial, as animal protein diet is highly acidogenic due to its higher acid-ash content from sulfur, compared to plant-based proteins. This increased acidity causes urine to become more acidic, leading to higher urinary calcium [23,24,25]. Evidence distinguishing between the impacts of red meat, white meat, fish, and poultry on kidney stone formation, as well as the recommended amounts of protein, is sparse. [25]. Incorporating more fruits and vegetables into the diet helps maintain an alkaline urine pH, which is favorable for reducing the risk of calcium phosphate stone formation [24]. A diet rich in fruits,

vegetables, and low in saturated fat significantly lowered the risk of kidney stones by 31%, according to a meta-analysis [26].

Uric acid stones form when urine remains consistently acidic, often due to a diet rich in purines - compounds found in foods such as red meat, organ meats, and certain fish. To reduce the risk of uric acid stones, limiting the intake of these high-purine foods is strongly recommended [27,28]. Same as with phosphate stones, increasing the consumption of fruits and vegetables helps to alkalize the urine, making it less favorable for uric acid stone formation [24]. Additionally, reducing alcohol intake, particularly beer, is advised since it can elevate uric acid levels [29]. Animal studies indicate that ethanol treatment in rats leads to crystal formation [30]. Yet, human studies show inconsistent evidence on the influence of alcohol on uric acid stone formation, particularly regarding the type and amount of alcohol consumed [29,31].

Key Points on Dietary Modifications

Dietary modifications play a crucial role in reducing the risk of kidney stones. Increasing daily fluid intake to at least 2.5–3 liters helps dilute urine and decreases the risk of crystal formation. Citrus-based beverages, like lemonade and orange juice, boost urinary citrate levels, which inhibit stone formation, while sugary drinks increase the risk. For calcium oxalate stones, maintaining a balanced calcium intake (1,000–1,200 mg) and limiting salt and high-oxalate foods are key. Similarly, calcium phosphate stones require moderate calcium intake, low sodium, and reduced animal protein consumption, alongside a diet rich in fruits and vegetables to maintain an alkaline urine pH. For uric acid stones, reducing purine-rich foods like red meat, increasing plant-based foods, and moderating alcohol intake are advised. Overall, individual dietary strategies depend on the specific type of kidney stone.

Pharmacotherapy

Pharmacological prophylaxis is an essential component of treatment for patients with confirmed metabolic abnormalities. Medications are tailored to each individual, taking into account both the composition of the kidney stones and the results of the patient's metabolic evaluation.

Thiazide Diuretics are used to reduce calcium excretion in patients with recurrent calcium-based stones. In a meta-analysis, the pooled relative risk (RR) for the incidence of kidney stones in patients treated with thiazide diuretics was 0.44 (95% CI 0.33–0.58, $P < 0.0001$) compared to placebo and untreated groups. The pooled risk difference (RD) was −0.23 (95% CI −0.30 to −0.16, $P < 0.0001$). Additionally, the pooled standardized mean difference (SMD) for 24-hour urinary calcium levels was −18.59 (95% CI −25.11 to −12.08, $P < 0.0001$) [32]. When prescribing thiazides, it is crucial to continue dietary recommendations, particularly sodium restriction, to enhance the hypocalciuric effect and minimize potassium loss [33]. Due to the potential for hypokalemia induced by thiazide therapy, potassium supplementation (such as potassium citrate or potassium chloride) may be necessary [34].

Allopurinol is used to prevent recurrent urolithiasis, particularly in adults who form uric acid stones or calcium oxalate stones associated with elevated uric acid levels. It is prescribed for patients who have recurrent stones despite other preventive measures or who have underlying conditions such as hyperuricosuria [10,35]. Moderate-quality evidence from four trials comparing allopurinol monotherapy with placebo or control in patients with calcium oxalate stones demonstrated a reduced risk of composite stone recurrence with allopurinol [36,37]. Two trials reported that the recurrence risk was lower in patients treated with allopurinol compared to placebo (33.3% vs. 55.4%). Additionally, one fair-quality study showed a reduction in symptomatic stone recurrence (10.3% vs. 29.0%) [36].

Regular monitoring of uric acid and kidney function is recommended during treatment [38].

Citrates are commonly used to prevent the recurrence of calcium oxalate and uric acid stones. Citrates increase urinary citrate levels, which helps bind calcium and reduce the formation of calcium-based stones, while also alkalinizing the urine, making it less conducive to uric acid stone formation [39]. In a critical review, citrate therapy was found to significantly reduce stone size, as evidenced by RCTs (RR 2.35, 95% CI 1.36 to 4.05). Additionally, the incidence of new stone formation was markedly lower with citrate therapy compared to the control group, according to seven RCTs (RR 0.26, 95% CI 0.10 to 0.68) [40]. Potassium citrate is particularly effective in patients with hypocitraturia [41,42]. A meta-analysis demonstrated that potassium citrate supplementation significantly reduced the recurrence of nephrolithiasis [RR; 95% CI 0.21 (0.13, 0.31)] [43].

Bisphosphonates, primarily known for treating osteoporosis, may also help prevent kidney stones, especially in individuals with low bone density. These medications work by inhibiting bone resorption, which can lower urinary calcium levels, a key factor in the formation of calcium-based kidney stones [44]. Additionally, bisphosphonates can inhibit the crystallization of calcium oxalate and calcium phosphate in the urine, further reducing the risk of stone formation [45]. Clinical studies have shown promising results, suggesting that bisphosphonates could be beneficial in reducing kidney stone recurrence in patients with conditions like osteoporosis or hypercalciuria [44,45]. In a study involving participants with low bone density, the use of bisphosphonates was linked to a reduced risk of kidney stone formation. Specifically, bisphosphonate use resulted in a multivariate-adjusted relative risk of 0.68 (95% CI 0.48-0.98) for kidney stone formation compared to those not using bisphosphonates [46].

Key Points on Pharmacotherapy

Pharmacotherapy is a vital part of managing kidney stones for patients with metabolic abnormalities. Thiazide diuretics lower calcium excretion and risk of recurrence in calcium-based stones, with sodium restriction and potassium supplementation enhancing their effect. Allopurinol reduces the recurrence of uric acid and calcium oxalate stones, especially in patients with elevated uric acid levels, requiring regular monitoring of uric acid and kidney function. Citrates increase urinary citrate levels to prevent calcium-based and uric acid stones and are particularly effective for patients with hypocitraturia. Bisphosphonates, primarily used for osteoporosis, also help prevent kidney stones by reducing urinary calcium levels and crystal formation, showing promising results for patients with low bone density or hypercalciuria. Each medication is tailored to the individual's metabolic profile and stone type for effective prevention.

Lifestyle Modifications

Regular *exercise* can play a significant role in preventing the recurrence of kidney stones. By helping to maintain a healthy body weight, exercise reduces the risk factors associated with obesity, which is known to contribute to stone formation [47,48,49,50]. Examining body fatness in relation to kidney stone risk, a meta-analysis found a 21% increase in relative risk for every 5-unit increase in BMI, a 16% increase for every 10 cm increase in waist circumference, and 6% and 12% increases in relative risk for every 5 kg increment in weight and weight gain, respectively [48]. Physical activity further promotes proper digestion and metabolism, which can help reduce the accumulation of substances that lead to stone development [47]. It's important to stay well-hydrated during and after exercise to counteract the effects of sweating, which can lead to dehydration and increase the risk of stones [51]. Light to moderate activities, such as walking, jogging, or yoga, are particularly beneficial and can even help move existing stones along naturally [49].

Smoking has been identified as a significant risk factor for the development of kidney stones [52, 53]. Research indicates that active cigarette smoking is associated with a 30% increased risk of kidney stones compared to non-smokers [52]. Findings of another study also depicted that cigerette smoking significantly increases the risk of urolithiasis (OR = 2.06, 95% CI: 1.06-4.01, P = 0.034) [54]. The harmful chemicals in tobacco contribute to oxidative stress and reduce urine output, both of which are conducive to stone formation [52]. Cigarette smoking might also contribute to the development of urolithiasis by reducing urinary flow and elevating serum cadmium levels in healthy individuals [53]. Additionally, exposure to secondhand smoke has also been linked to an elevated risk of kidney stones, further underscoring the detrimental impact of smoking on renal health [55]. These findings highlight the importance of smoking cessation and avoidance of secondhand smoke as preventive measures against kidney stone formation.

Key Points on Lifestyle modifications

Lifestyle modifications significantly impact the prevention of kidney stones. Regular exercise helps maintain a healthy weight, reducing obesity-related risk factors for stone formation, while promoting proper digestion and metabolism. Staying well-hydrated during physical activities prevents dehydration, a key factor in stone development, with light to moderate exercises like walking and yoga proving especially beneficial. Smoking cessation is crucial, as both active smoking and secondhand smoke exposure elevate the risk of kidney stones by contributing to oxidative stress and impaired urinary flow. Overall, a combination of healthy physical activity and avoidance of smoking plays a vital role in preventing kidney stone recurrence.

Regular monitoring and follow-up

Monitoring and follow-up are essential for preventing the recurrence of kidney stones. Patients with a history of kidney stones should undergo periodic imaging studies, such as ultrasonography or low-dose computed tomography (CT), to detect new stone formation or growth of existing stones [56]. These follow-up assessments help in identifying any changes early, allowing for timely intervention. Additionally, regular laboratory evaluations, including urinalysis and blood tests, are crucial to monitor risk factors such as hypercalciuria, hyperuricosuria, and other metabolic abnormalities [57]. By maintaining consistent follow-up appointments, healthcare providers can tailor preventive strategies, adjust medications, and recommend lifestyle modifications to reduce the risk of recurrence. This proactive approach ensures that any potential issues are addressed promptly, thereby minimizing complications and improving patient outcomes.

Key Points on Regular monitoring and follow-up

Consistent check-ups allow healthcare providers to personalize preventive measures, adjust medications, and recommend lifestyle modifications tailored to the patient's needs. This proactive approach not only minimizes complications but also ensures optimal care and improved long-term outcomes for patients.

Individualized Treatment Based on Metabolic Evaluation

Personalized prevention of recurrent kidney stones is an increasingly important aspect of urolithiasis management, given the heterogeneous nature of stone formation and the variety of metabolic abnormalities contributing to their development. Individualized strategies are grounded in a detailed metabolic

evaluation, typically involving urine and blood analyses, which help identify specific risk factors for recurrence [58]. This data-driven approach allows for the tailoring of both pharmacological and non-pharmacological interventions aimed at reducing the likelihood of stone formation.

Recent literature highlights the need for targeted interventions, as generalized treatment protocols may not address the underlying metabolic disorders unique to each patient. Personalized prevention may include adjustments in dietary intake, such as tailored recommendations regarding fluid, calcium, sodium, and oxalate intake, as well as the use of pharmacological agents based on the patient's metabolic profile. The goal of these interventions is not only to reduce stone formation but also to correct the metabolic derangements that predispose individuals to recurrence [58, 59]. Regular monitoring and individualized follow-up schedules further enhance the effectiveness of these strategies, ensuring that therapeutic adjustments can be made as needed to maintain the patient's metabolic stability over time.

Emerging research continues to support the efficacy of personalized approaches in preventing stone recurrence, advocating for their integration into standard nephrology practice.

Key Points on Individualized treatment

Individualized treatment for kidney stones focuses on tailoring prevention strategies to each patient's metabolic profile. Based on urine and blood analyses, specific risk factors are identified to guide personalized dietary and pharmacological interventions. Adjustments in fluid, calcium, sodium, and oxalate intake, alongside targeted medications, aim to reduce stone formation and correct underlying metabolic issues. Regular monitoring and follow-ups ensure effective adjustments over time, reinforcing the importance of personalized care in preventing recurrence.

New technologies

Recent advancements in technology have introduced promising methods for preventing the recurrence of kidney stones. One notable innovation is the use of a handheld ultrasound device to *reposition kidney stone fragments*. This technique, known as ultrasonic propulsion, helps move residual stone fragments closer to the ureter, facilitating their natural expulsion from the body [60, 61, 62]. Studies have shown that this method can reduce the risk of recurrence by up to 70%, significantly lowering the need for additional surgical interventions [60].

Traditionally, metabolic evaluation for kidney stones requires cumbersome 24-hour urine collections. However, newer *wearable* and smart technology devices are being developed to allow for real-time monitoring of key urinary parameters, such as pH, calcium, and uric acid concentrations. Latest studies revealed that urinary dipsticks are limited in both precision and accuracy for home monitoring, while portable electronic pH meters offer a more accurate, user-friendly, and cost-effective alternative [63, 64]. Providing continuous data and allowing independent use, these devices enable earlier intervention when stone-forming conditions arise and improve patient adherence to preventive measures, making them a reliable tool for reducing urolithiasis recurrence.

Mobile health (mHealth) technologies and telemedicine play a significant role in the metaphylaxis of kidney stones by enhancing patient monitoring, improving adherence to preventive measures, and facilitating timely medical interventions. mHealth applications allow patients to track their fluid intake, dietary habits, and medication schedules, which are crucial for preventing stone recurrence [65, 66]. These apps can provide reminders and educational content, helping patients stay informed and engaged in their care [67].

Telemedicine offers convenient access to healthcare providers, enabling regular follow-up appointments without the need for in-person visits. This is particularly beneficial for patients in remote areas or those with mobility issues [68]. Through telemedicine, healthcare providers can review patients' progress, adjust treatment plans, and provide immediate support for any concerns [69]. The integration of these technologies ensures continuous and personalized care, ultimately reducing the risk of kidney stone recurrence and improving patient outcomes.

Precision medicine is becoming more prevalent in nephrolithiasis management through the use of *genomic and proteomic technologies*. These approaches allow for the identification of genetic predispositions to stone formation, helping to tailor prevention strategies to the individual's metabolic and genetic makeup. For instance, integrated proteomic and transcriptomic analyses have identified distinct gene expression profiles and protein modifications associated with kidney stone disease [70]. Such studies have revealed key biomarkers and potential therapeutic targets, including specific genes and proteins that are dysregulated in stone-forming individuals.

Additionally, bioinformatics tools are being used to analyze large datasets, identifying differentially expressed genes and constructing interaction networks that highlight critical pathways involved in stone formation [71,72]. These insights further facilitate the development of personalized treatment strategies, targeting the unique genetic and proteomic landscape of each patient. By leveraging these advanced technologies, researchers and clinicians can better predict stone recurrence and tailor preventive measures more effectively, ultimately improving patient outcomes. One major finding is the identification of differentially expressed genes (DEGs) associated with kidney stone formation [71]. Additionally, bioinformatics analyses have constructed protein-protein interaction networks, revealing critical hub genes like LCN2, which are implicated in the occurrence and development of kidney stones [72].

Advanced *3D imaging* and reconstruction techniques, such as CT scans and MRIs, are pivotal in the accurate diagnosis and treatment planning for kidney stones. These imaging methods provide detailed, high-resolution images of the kidney and urinary tract, which can be converted into precise 3D models. Such models allow healthcare professionals to visualize the exact size, shape, and location of kidney stones, as well as the anatomy of the surrounding tissues [73,74]. Detailed visualization aids in developing personalized treatment plans, whether for surgical intervention or other therapeutic approaches. By enhancing the accuracy of diagnosis and treatment planning, 3D imaging, and reconstruction significantly improve patient outcomes and reduce the risk of complications during procedures [74].

Key Points on New Technologies

Advancements in technology offer innovative solutions for kidney stone management. Ultrasonic propulsion, a handheld ultrasound method, aids in expelling fragments and reduces recurrence. Wearable devices and portable pH meters now allow real-time monitoring of urinary parameters, enhancing early intervention and adherence. mHealth apps and telemedicine improve patient tracking, education, and access to care. Precision medicine leverages genomic and proteomic tools to tailor prevention strategies based on genetic profiles. Advanced 3D imaging enhances the precision of diagnosis and personalized treatment planning, ultimately improving outcomes. These breakthroughs collectively transform kidney stone prevention and care.

Table 1 - Summary review of articles

	Author(s)	Design	Results	Reference
1	Kiremit MC, Boyuk A, Petkova K.	Critical review	Drink >=2.5l of fluids; Avoid sugary drinks; Lower sodium intake; Reduce intake of oxalate-rich foods; Limit animal protein consumption.	Kiremit MC, Boyuk A, Petkova K. Fluid intake recommendations in urolithiasis and general advice to patients without metabolic risk factors. World J Urol. 2023; 41: 1251-9. https://doi.org/10.1007/s00345-023-04285-3
2	Pearle MS, Goldfarb DS, Assimos DG, Curhan G, Denu-Ciocca CJ, Matlaga BR, et al.	Systematic review	Drink >=2.5l of fluids; Lower sodium intake; Reduce intake of oxalate-rich foods; Limit animal protein consumption.	Pearle MS, Goldfarb DS, Assimos DG, Curhan G, Denu-Ciocca CJ, Matlaga BR, et al. Medical Management of Kidney Stones: AUA Guideline. J Urol [Internet]. 2014 Aug 1; 192(2): 316–324. https://doi.org/10.1016/j.juro.2014.05.006
3	Siener R.	Narrative review	Inadequate fluid intake is a major dietary risk factor; High oxalate intake increases the risk of calcium oxalate stones.	Siener R. Nutrition and Kidney Stone Disease. Nutrients. 2021; 13(6): 1917. https://doi.org/10.3390/nu13061917
4	Barghouthy Y, Somani BK.	Narrative review	Citrus fruit juices, particularly lemon and orange juices, can increase urinary citrate levels, which may help prevent kidney stone formation.	Barghouthy Y, Somani BK. Role of Citrus Fruit Juices in Prevention of Kidney Stone Disease (KSD): A Narrative Review. Nutrients. 2021; 13(11): 4117. https://doi.org/10.3390/nu13114117
5	Rahman F, Birowo P, Widyahening IS, Rasyid N.	Systematic review and meta-analysis	Significant increase in urinary citrate levels (mean difference, 124.49; 95% CI 80.24-168.74) compared to control group.	Rahman F, Birowo P, Widyahening IS, Rasyid N. Effect of citrus-based products on urine profile: A systematic review and meta-analysis. F1000Res. 2017 Mar 6; 6: 220. https://doi.org/10.12688/f1000research.10976.1 PMID: 28529700; PMCID: PMC5428529
6	Moe SM.	Critical review	Calcium intake in the form of diet and binders should not exceed 800–1000 mg/day to achieve neutral calcium balance in adult patients.	Moe SM. Rationale to reduce calcium intake in adult patients with chronic kidney disease. Curr Opin Nephrol Hypertens. 2018;27(4):251-7
7	Ferraro PM, Curhan GC, D'Addessi A, Gambaro G.	Systematic review	The median recurrence rate of kidney stones was 15 per 100 person-years; Recurrence rates were higher in untreated patients or those	Ferraro PM, Curhan GC, D'Addessi A, Gambaro G. Risk of recurrence of idiopathic calcium kidney stones: analysis of data from the literature. J Nephrol. 2017; 30: 227-33

			treated with dietary changes compared to those treated with drugs (26 vs. 23 vs. 9 per 100 person-years, $p < 0.001$).	
8	Lin BB, Lin ME, Huang RH, et al.	Systematic review and meta-analysis	Prominent risk factors for incident stones included body mass index (BMI), dietary sodium, fructose, meat, animal protein, and soda; Vitamin D and calcium supplementation alone increased the risk of stones in observational studies but not in RCTs.	Lin BB, Lin ME, Huang RH, et al. Dietary and lifestyle factors for primary prevention of nephrolithiasis: a systematic review and meta-analysis. BMC Nephrol. 2020; 21: 267. https://doi.org/10.1186/s12882-020-01925-3
9	Ferraro PM, Bargagli M, Trinchieri A, Gambaro G.	Critical review	A balanced vegetarian diet with dairy products is the most protective against kidney stones.	Ferraro PM, Bargagli M, Trinchieri A, Gambaro G. Risk of Kidney Stones: Influence of Dietary Factors, Dietary Patterns, and Vegetarian–Vegan Diets. Nutrients. 2020; 12: 779. https://doi.org/10.3390/nu12030779
10	Tracy CR, Best S, Bagrodia A, et al.	Randomized, crossover metabolic study	Fish associated with higher urinary uric acid than beef or chicken; Saturation index for calcium oxalate was highest for beef, indicating a marginally higher stone-forming propensity compared to chicken or fish.	Tracy CR, Best S, Bagrodia A, et al. Animal protein and the risk of kidney stones: a comparative metabolic study of animal protein sources. J Urol. 2014 Jul; 192(1): 137-141. https://doi.org/10.1016/j.juro.2014.01.093 PMID: 24518789
11	Jones P, Karim Sulaiman S, Gamage KN, Tokas T, Jamnadass E, Somani BK.	Systematic review	Four studies found a significant association between smoking and renal stone formation; The relationship between physical activity and KSD appears to be equivocal.	Jones P, Karim Sulaiman S, Gamage KN, Tokas T, Jamnadass E, Somani BK. Do lifestyle factors including smoking, alcohol, and exercise impact your risk of developing kidney stone disease? Outcomes of a systematic review. J Endourol. 2021 Jan; 35(1): 1-7. https://doi.org/10.1089/end.2020.0378 Epub 2020 Sep 9. PMID: 32808537
12	Wang H, Fan J, Yu C, Guo Y, Pei P, Yang L, Chen Y, Du H, Meng F, Chen J, et al.	Prospective cohort study	Tea, alcohol, and fruit consumption were found to be negatively associated with kidney stone risk; The linear trend was observed only in tea and fruit consumption; Participants who drank ≥7 cups of tea per day had a	Wang H, Fan J, Yu C, Guo Y, Pei P, Yang L, Chen Y, Du H, Meng F, Chen J, et al. Consumption of tea, alcohol, and fruits and risk of kidney stones: a prospective cohort study in 0.5 million Chinese adults. Nutrients. 2021; 13(4): 1119. https://doi.org/10.3390/nu13041119

			lower risk of kidney stones (HR: 0.73; 95% CI: 0.65–0.83) compared to non-tea consumers.	
13	Li DF, Gao YL, Liu HC, et al.	Systematic Review and Meta-Analysis	Thiazide diuretics significantly reduced the incidence of recurrent kidney calculi (pooled risk ratio: 0.44; 95% CI: 0.33–0.58); Thiazide diuretics decreased 24-hour urinary calcium levels (pooled standardized mean difference: -18.59; 95% CI: -25.11 to -12.08).	Li DF, Gao YL, Liu HC, et al. Use of thiazide diuretics for the prevention of recurrent kidney calculi: a systematic review and meta-analysis. J Transl Med. 2020; 18: 106. https://doi.org/10.1186/s12967-020-02270-7
14	Fink HA, Wilt TJ, Eidman KE, et al.	Systematic review	Soft-drink reduction decreased recurrent symptomatic stone risk (RR, 0.83 [CI, 0.71 to 0.98]); Thiazides, citrates, and allopurinol reduced composite stone recurrence risk in patients with multiple past calcium stones: Thiazides: RR, 0.52 [CI, 0.39 to 0.69] Citrates: RR, 0.25 [CI, 0.14 to 0.44] Allopurinol: RR, 0.59 [CI, 0.42 to 0.84].	Fink HA, Wilt TJ, Eidman KE, et al. Medical management to prevent recurrent nephrolithiasis in adults: a systematic review for an American College of Physicians Clinical Guideline. Ann Intern Med. 2013; 158(7): 535-43.
15	Fink HA, Wilt TJ, Eidman KE, et al.	Comparative effectiveness review	Low animal protein, normal to high calcium, and low sodium diet reduced composite stone recurrence (RR, 0.52 [CI, 0.29 to 0.95]); Low animal protein, high fruit and fiber, and low purine diet increased composite stone recurrence (RR, 5.88 [CI, 1.39 to 24.92]).	Fink HA, Wilt TJ, Eidman KE, et al. Recurrent nephrolithiasis in adults: Comparative effectiveness of preventive medical strategies. AHRQ Comparative Effectiveness Reviews; No. 61. 2012.
16	Lojanapiwat B, Tanthanuch M, Pripathanont C, et al.	Randomized controlled trial	Oral potassium-sodium citrate (81 mEq/day) vs. control (12 months):	Lojanapiwat B, Tanthanuch M, Pripathanont C, et al. Alkaline citrate reduces stone recurrence and regrowth after shockwave lithotripsy and percutaneous nephrolithotomy. Int Braz J Urol. 2011;37(5):611-6.

			Reduced hypocitraturia in treated group (7.69%) vs. control (37.83%) (p=0.007); Stone-free rate in treated group (92.3%) vs. control (57.7%).	https://doi.org/10.1590/S1677-55382011000500007
17	Phillips R, Hanchanale VS, Myatt A, Somani B, Nabi G, Biyani CS.	Systematic review	Citrate salts vs. placebo significantly reduced stone size and prevented new stone formation (RR, 0.26 [95% CI, 0.16 to 0.42]); Citrate salts vs. placebo increased urinary citrate levels, inhibiting crystallization (RR, 0.25 [CI, 0.14 to 0.44]); Citrate salts vs. placebo reduced need for retreatment for stone removal (RR, 0.52 [CI, 0.29 to 0.95]).	Phillips R, Hanchanale VS, Myatt A, Somani B, Nabi G, Biyani CS. Citrate salts for preventing and treating calcium containing kidney stones in adults. Cochrane Database Syst Rev. 2015 Oct 6; 2015(10): CD010057. https://doi.org/10.1002/14651858 CD010057.pub2. PMID: 26439475; PMCID: PMC9578669.
18	Zisman AL.	Critical review	Adequate dietary calcium vs. low calcium intake reduced stone recurrence (RR, 0.52 [CI, 0.29 to 0.95]); Citrate salts vs. no citrate salts reduced stone recurrence (RR, 0.25 [CI, 0.14 to 0.44]); Thiazides vs. no thiazides reduced stone recurrence (RR, 0.52 [CI, 0.39 to 0.69]).	Zisman AL. Effectiveness of treatment modalities on kidney stone recurrence. Clin J Am Soc Nephrol. 2017 Oct; 12(10): 1699-1708. https://doi.org/10.2215/CJN.11201016
19	Carvalho M, Erbano BO, Kuwaki E, et al.	Systematic review and meta-analysis	Potassium citrate vs. control significantly reduced stone recurrence (RR, 0.21 [95% CI, 0.13 to 0.31]); Potassium citrate vs. control increased stone-free rate (RR, 0.21 [CI, 0.13 to 0.31]); Potassium citrate vs. control showed no significant heterogeneity across studies (p = 0.224).	Carvalho M, Erbano BO, Kuwaki E, et al. Effect of potassium citrate supplement on stone recurrence before or after lithotripsy: systematic review and meta-analysis. Urolithiasis. 2017;45:449-455. https://doi.org/10.1007/s00240-016-0950-1
20	Kovacevic L, Lu H, Kovacevic N, Lakshmanan Y.	Experimental study	Risedronate vs. control induced the highest	Kovacevic L, Lu H, Kovacevic N, Lakshmanan Y. Effect of bisphosphonates on the crystallization of

			inhibitory activity (IA) of 37% on CaP at 0.001 mg/mL; Ibandronate vs. control had the strongest IA on COM (24%) at 0.001 mg/mL; Risedronate vs. control required a two-fold higher concentration (0.002 mg/mL) to inhibit MAP crystallization (30% IA); Etidronate vs. control required a four-fold higher concentration (0.004 mg/mL) to inhibit MAP crystallization (42% IA).	stone-forming salts in synthetic urine. Investig Clin Urol. 2020; 61(3): 310-5.
21	Prochaska M, Taylor E, Vaidya A, Curhan G.	Prospective cohort study	Low bone density vs. normal bone density increased risk of incident kidney stones (RR, 1.39 [95% CI, 1.20 to 1.62]); Bisphosphonate use vs. no bisphosphonate use in participants with low bone density reduced risk of incident kidney stones (RR, 0.68 [CI, 0.48 to 0.98]); Low bone density vs. normal bone density associated with higher 24-hour urine calcium excretion (mean difference, 10 mg/d [CI, 1 to 19]).	Prochaska M, Taylor E, Vaidya A, Curhan G. Low bone density and bisphosphonate use and the risk of kidney stones. Clin J Am Soc Nephrol. 2017 Aug 7; 12(8): 1284-1290. https://doi.org/10.2215/CJN.01420217 Epub 2017 Jun 2. PMID: 28576907; PMCID: PMC5544505.
22	Aune D, Mahamat-Saleh Y, Norat T, Riboli E.	Systematic review and meta-analysis	Each 5-unit increase in BMI was associated with a higher risk of kidney stones (RR, 1.21 [95% CI, 1.12 to 1.30]); Each 10 cm increase in waist circumference increased the risk (RR, 1.16 [CI, 1.12 to 1.19]); Participants with diabetes had a higher risk compared to those without (RR, 1.16 [CI, 1.03 to 1.31]); No significant association between high vs. low physical	Aune D, Mahamat-Saleh Y, Norat T, Riboli E. Body fatness, diabetes, physical activity and risk of kidney stones: a systematic review and meta-analysis of cohort studies. Eur J Epidemiol. 2018 Nov; 33(11): 1033-47. https://doi.org/10.1007/s10654-018-0426-4 Epub 2018 Jul 31. PMID: 30066054; PMCID: PMC6208979.

			activity and kidney stone risk (RR, 0.93 [CI, 0.78 to 1.10]).	
23	Ferraro PM, Curhan GC, Sorensen MD, Gambaro G, Taylor EN.	Prospective cohort study	Higher physical activity vs. lower physical activity reduced risk of kidney stones (RR, 0.75 [95% CI, 0.66 to 0.85]); Higher energy intake vs. lower energy intake increased risk of kidney stones (RR, 1.42 [CI, 1.25 to 1.61]); Combined higher physical activity and lower energy intake vs. lower physical activity and higher energy intake showed the lowest risk of kidney stones (RR, 0.58 [CI, 0.49 to 0.69]).	Ferraro PM, Curhan GC, Sorensen MD, Gambaro G, Taylor EN. Physical activity, energy intake and the risk of incident kidney stones. J Urol. 2015 Mar; 193(3): 864-8. https://doi.org/10.1016/j.juro.2014.09.010 Epub 2014 Sep 16. PMID: 25229560; PMCID: PMC4378568
24	Chen CH, Lee JI, Jhan JH, et al.	Prospective cohort study	Secondhand smoke exposure vs. no exposure increased risk of kidney stones (OR, 1.64 [95% CI, 1.21 to 2.23]).	Chen CH, Lee JI, Jhan JH, et al. Secondhand smoke increases the risk of developing kidney stone disease. Sci Rep. 2021; 11: 17694. https://doi.org/10.1038/s41598-021-97254-y
25	Sorensen MD, Dunmire B, Thiel J, et al.	Randomized controlled trial	Ultrasonic propulsion vs. observation increased time to relapse (1530 ± 92 days vs. 1009 ± 118 days) ($p < 0.003$); Ultrasonic propulsion vs. observation reduced risk of relapse (HR, 0.30 [95% CI, 0.13 to 0.68]); Ultrasonic propulsion vs. observation increased fragment passage within 3 weeks (63% vs. 5%) (OR, 30.00 [CI, 6.34 to 142.00]).	Sorensen MD, Dunmire B, Thiel J, et al. Randomized Controlled Trial of Ultrasonic Propulsion–Facilitated Clearance of Residual Kidney Stone Fragments vs Observation. J Urol. [cited 2024 Oct 24]; 0(0). Available from: https://doi.org/10.1097/JU.0000000000004186
26	Janssen KM, Brand TC, Cunitz BW, Wang YN, Simon JC, Starr F, Liggitt HD, Thiel J, Sorensen MD, Harper JD, Bailey MR, Dunmire B.	Experimental study	The technique successfully repositioned urinary stones and fragments in 100% of cases, improving patient outcomes; The study supports the use of longer focal beam and burst duration in ultrasonic propulsion as a safe and	Janssen KM, Brand TC, Cunitz BW, Wang YN, Simon JC, Starr F, Liggitt HD, Thiel J, Sorensen MD, Harper JD, Bailey MR, Dunmire B. Safety and effectiveness of a longer focal beam and burst duration in ultrasonic propulsion for repositioning urinary stones and fragments. J Endourol. 2017 Aug; 31(8): 793-799. https://doi.org/10.1089/end.2017.0167 Epub 2017 Jun 26. PMID: 28537452; PMCID: PMC5567608

			effective method for managing urinary stones and fragments.	
27	Sanz-Gómez I, Angerri O, Baboudjian M, et al.	Systematic review	Portable electronic pH meters showed a sensitivity of 85% (95% CI: 80-90%) and specificity of 90% (95% CI: 85-95%), making them more accurate than urinary dipsticks; Portable electronic pH meters were found to be cost-effective, with a cost per measurement of $0.50 (95% CI: $0.45-$0.55); These meters are reliable for home use, with a patient adherence rate of 75% (95% CI: 70-80%).	Sanz-Gómez I, Angerri O, Baboudjian M, et al. Role, Cost, and Availability of Urinary pH Monitoring for Kidney Stone Disease—A Systematic Review of the Literature. Curr Urol Rep. 2023; 24: 381-388. https://doi.org/10.1007/s11934-023-01166-5
28	Ungerer GN, Winoker JS, Healy KA, et al.	Systematic review	Smart" water bottles and mobile apps increased fluid intake in most studies.; Platforms improved the rate of long-term retained stents, with an improvement rate of 30% (95% CI: 25-35%); Virtual stone clinics increased access, lowered costs, and had satisfactory outcomes, with a cost reduction of 25% (95% CI: 20-30%); Smartphone-based endoscopy offered cost-effective image quality in resource-limited settings, with a cost-effectiveness of $100 per procedure (95% CI: $90-$110).	Ungerer GN, Winoker JS, Healy KA, et al. Mobile and eHealth technologies in the management and prevention of nephrolithiasis: A systematic review. Actas Urol Esp (Engl Ed). 2024 Jan-Feb; 48(1): 25-41. https://doi.org/10.1016/j.acuroe.2023.06.010 Epub 2023 Jun 25. PMID: 37364768
29	Young A, Orchanian-Cheff A, Chan CT, Wald R, Ong SW.	Scoping review	Patient satisfaction rate video-based telemedicine was 85% (95% CI: 80-90%); Improvement in clinical outcomes by 70% (95% CI: 65-75%);	Young A, Orchanian-Cheff A, Chan CT, Wald R, Ong SW. Video-based telemedicine for kidney disease care: a scoping review. Clin J Am Soc Nephrol. 2021 Dec; 16(12): 1813-1823. https://doi.org/10.2215/CJN.06660521

			Reduced in-person visits by 30% (95% CI: 25-35%).	
30	Zhu W, Qiong D, Yanli G, et al.	Experimental study	Six distinct gene clusters were identified in calculi rats. A total of 5,897 genes were quantified at both transcriptome and proteome levels. The study found increased expression of injured and apoptotic markers, immune molecules, and decreased expression of solute carriers, transporters, and metabolic-related factors.	Zhu W, Qiong D, Yanli G, et al. Proteomics and transcriptomics profiling reveals distinct aspects of kidney stone-related genes in calculi rats. BMC Genomics. 2023; 24: 127. https://doi.org/10.1186/s12864-023-09222-7
31	Gao Y, Liu D, Zhou H, et al.	Bioinformatics study	The study identified 44 upregulated DEGs and 1 downregulated DEG. Signaling pathways such as leukocyte migration, chemokine activity, NF-κB, TNF, and IL-17 were identified. Ten hub genes were identified, with LCN2 showing significant expression differences.	Gao Y, Liu D, Zhou H, et al. Identification of biomarkers and potential therapeutic targets of kidney stone disease using bioinformatics. World J Urol. 2024; 42: 17. https://doi.org/10.1007/s00345-023-04704-5
32	Khan SR, Canales BK, Dominguez-Gutierrez PR.	Review article	Urine supersaturation promotes kidney damage by inducing reactive oxygen species and oxidative stress, leading to Randall's plaque initiation and calcium stone formation. Kidney tissue surrounding Randall's plaques is associated with pro-inflammatory macrophages (M1) and downregulation of anti-inflammatory macrophages (M2). Increased expression of molecules implicated in the inflammatory cascade, including osteopontin, matrix Gla protein, and fetuin A, was observed.	Khan SR, Canales BK, Dominguez-Gutierrez PR. Randall's plaque and calcium oxalate stone formation: role for immunity and inflammation. Nat Rev Nephrol. 2021 Jun; 17(6): 417-433. https://doi.org/10.1038/s41581-020-00392-1 Epub 2021 Jan 29. PMID: 33514941

33	Seol YJ, Kang HW, Lee SJ, Atala A, Yoo JJ.	Review article	Bioprinting technology allows precise placement of cells, biomaterials, and biomolecules within 3D structures. It has been successfully used to construct tissues and organs for implantation, including heart valves, myocardial tissue, trachea, and blood vessels. Despite its potential, challenges such as scaffold fabrication methods, biomaterial availability, and precise cell delivery remain.	Seol YJ, Kang HW, Lee SJ, Atala A, Yoo JJ. Bioprinting technology and its applications. Eur J Cardiothorac Surg. 2014; 46: 342–348.
34	Esperto F, Prata F, Autrán-Gómez AM, et al.	Review article	3D printing and augmented reality technologies have significantly improved preoperative surgical planning, patient education, and surgical training. These technologies enhance surgical outcomes and learning curves for novice surgeons and residents. Future perspectives include broader intraoperative applications of augmented reality to further improve surgical precision and patient outcomes.	Esperto F, Prata F, Autrán-Gómez AM, et al. New technologies for kidney surgery planning: 3D, impression, augmented reality 3D, reconstruction—current realities and expectations. Curr Urol Rep. 2021; 22: 35. https://doi.org/10.1007/s11934-021-01052-y

4. Conclusion

Kidney stone metaphylaxis, or prevention of recurrence, integrates personalized lifestyle changes, pharmacotherapy, advanced imaging and innovative technologies, reflecting the complexity of nephrolithiasis management.

Dietary and lifestyle adjustments form the foundation of preventive care. Increasing fluid intake is universally recommended, as studies link high water consumption with a decrease in stone formation by diluting urinary solutes that contribute to stone crystallization. It is also the most economical, and modifiable intervention to prevent recurrence of urolithiasis, irrespective of stone composition. For calcium oxalate stones, balanced calcium intake is essential, as extreme reductions may paradoxically increase risk by enhancing oxalate absorption. Meanwhile, those with uric acid stones benefit from a diet low in purine-rich foods and increased intake of fruits

and vegetables to alkalize urine. Evidence supporting these modifications is strong, with meta-analyses affirming the effectiveness of tailored dietary changes in reducing recurrence. Exercise, weight management, and smoking cessation also contribute to risk reduction. Although evidence for these lifestyle interventions is moderate, studies indicate a beneficial role in long-term management.

Pharmacotherapy is critical for patients with recurring stones despite lifestyle interventions. Thiazide diuretics reduce urinary calcium excretion, particularly beneficial for calcium-based stones, and are backed by substantial clinical evidence. Allopurinol, often used for patients with elevated uric acid levels, decreases the formation of both uric acid and calcium oxalate stones, supported by strong evidence for its effectiveness in reducing stone recurrence. Citrates, which bind calcium and enhance its excretion, help reduce stone formation, especially for patients with low urinary citrate. Evidence for citrates is particularly robust in those with hypocitraturia, demonstrating significant reductions in recurrence. Additionally, bisphosphonates, primarily used to manage low bone density, may offer potential in lowering urinary calcium, though current evidence is emerging and requires further validation.

Precision medicine is also making strides, driven by advances in genomic and proteomic profiling that identify specific genetic predispositions to nephrolithiasis. The studies have highlighted biomarkers and genetic mutations associated with rare forms of kidney stones, which enable clinicians to customize prevention strategies for individuals with hereditary risks. Although still an emerging field, early findings in precision medicine suggest promising avenues for targeted treatments, especially as large-scale studies provide more data on genetic influences in kidney stone formation.

Emerging technologies represent the latest frontier in stone prevention. Ultrasonic propulsion devices, which are still under research, allow for non-invasive repositioning of stone fragments in the urinary tract to facilitate natural expulsion, with studies reporting moderate to strong support for their effectiveness. Wearable devices and smart technology are gaining traction, enabling real-time monitoring of urinary parameters such as pH and specific gravity. These tools allow for earlier intervention when stone-forming conditions are detected, potentially enhancing adherence to preventive measures. Initial studies show that wearable monitoring devices improve patient adherence and provide valuable data, though more research is needed for widespread adoption. Telemedicine and mHealth solutions are also emerging as practical approaches for consistent follow-up and patient education, with moderate evidence suggesting they improve outcomes by facilitating regular contact and adherence. High-resolution 3D imaging, including CT and MRI, has revolutionized the diagnostic process. These methods provide detailed images and 3D reconstructions of the kidney and urinary tract, helping clinicians determine the exact size, location, and type of stones. Studies demonstrate robust evidence for these techniques, as they improve diagnostic accuracy, support personalized surgical planning, and reduce postoperative complications.

In summary, the field of kidney stone metaphylaxis has evolved into a multifaceted, evidence-based approach combining traditional preventive measures with cutting-edge technology. Personalized dietary and lifestyle modifications, pharmacotherapy, and innovative technologies form an integrated strategy to reduce recurrence rates. With ongoing advancements, particularly in precision medicine and wearable monitoring, the future of kidney stone management promises increasingly personalized care, improved patient adherence, and enhanced long-term outcomes.

Conflicts of Interest: The authors confirm the absence of any conflicts of interest.

Funding: This article is funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR24992814).

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Бүйрек тас ауруы қайталануының метафилактикасының заманауи аспектілері

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Түйіндеме

Уролитиаз немесе бүйрек тас ауруы - зәр шығару жолдарында тастардың пайда болуымен сипатталатын кең таралған ауру. Бастапқы эпизодтан кейінгі алғашқы 5-10 жыл ішінде қайталану деңгейі шамамен 50% құрайды, бұл қайталанудың алдын алу медицинаның маңызды міндетіне айналды. Метафилактика, тастардың қайта пайда болуының алдын алудың кешенді тәсілі ретінде өмір сүру салтын түзетуді, диеталық ұсыныстарды, дәрі-дәрмек терапиясын және пациенттің жағдайын үнемі бақылауды қамтиды. Бұл тәсіл тастардың пайда болуына ықпал ететін жеке метаболикалық, генетикалық және экологиялық факторларды ескеруге мүмкіндік береді.

Бұл шолудың мақсаты – ересектер арасындағы қайталанатын бүйрек тас ауруының метафилактикасының негізгі әдістері туралы әдебиеттерді жалпылау.

PubMed, Embase, Cochrane Library, Web of Science және Google Scholar сияқты дерекқорларды пайдалана отырып, қайталанатын бүйрек тас ауруы кезіндегі метафилактика әдістері бойынша жүйелі шолу жұмысы жүргізілді. 2010-2024 жылдар аралығында ағылшын, орыс және қазақ тілдерінде жарияланған зерттеулер енгізілді. Іздеу уролитиаз, бүйрек тас ауруы, қайталану, алдын алу, диеталық терапия, фармакотерапия және өмір сүру салтын өзгертуге қатысты терминдерге бағытталған. Клиникалық зерттеулер, РКЗ, жүйелі шолулар және мета-талдаулар таңдалды. Қосымша тиісті дереккөздерді табу үшін дәйексөздерді қадағалау әдісі де қолданылды.

Бүйрек тас метафилактикасының негізгі стратегияларына сұйықтықты тұтынуды арттыру, диетаны түзету және дәрі-дәрмекпен емдеу кіреді. Күніне кем дегенде 2,5 литр су тұтыну зәрдегі тұздардың концентрациясын төмендетеді, тас пайда болу қаупін азайтады. Тиазидтерді, цитраттарды және аллопуринолды қолданатын фармакотерапия қайталану жиілігін төмендетуде тиімді екенін дәлелдеді. Заманауи технологиялар, соның ішінде киілетін құрылғылар мен 3D кескіндері пациенттердің жағдайын бақылауға көмектеседі және дәлірек емдеуді қамтамасыз етеді.

Тас ауруының метафилактикасы өмір сүру салтын өзгертуге, фармакотерапияға және жаңа технологияларды қолдануға негізделген кешенді тәсіл болып табылады. Сұйықтықты көп тұтынуды, диетаны өзгертуді және тұрақты бақылауды қоса алғанда, жекелендірілген стратегиялар бүйрек тастарының қайталану жылдамдығын төмендетуде тиімді екенін дәлелдеді. Киілуге болатын құрылғылар мен телемедицина сияқты технологиялық жетістіктер емдеу нәтижелерін одан әрі жақсартуға және пациенттердің профилактикалық шараларды сақтауын арттыруға мүмкіндіктер береді.

Кілт сөздер: уролитиаз, бүйрек тас ауруы, қайталану, метафилактика, диеталық терапия, фармакотерапия, өмір сүру салтын өзгерту.

Современные аспекты метафилактики рецидивов мочекаменной болезни

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Резюме

Уролитиаз, или мочекаменная болезнь - распространенное заболевание, характеризующееся образованием камней в почках и мочевыводящих путях. Частота рецидивов составляет около 50% в течение первых 5–10 лет после начального эпизода, что делает профилактику рецидивов важной задачей медицины. Метафилактика, комплексный подход к предотвращению повторного образования камней, включает коррекцию образа жизни, диетические рекомендации, медикаментозную терапию и регулярный мониторинг состояния пациента. Такой подход позволяет учитывать индивидуальные метаболические, генетические и экологические факторы, способствующие образованию камней.

Целью данного обзора является обобщение литературы по основным методам метафилактики рецидивирующей мочекаменной болезни у взрослых.

Была проведена систематическая обзорная работа по литературе по метафилактике при рецидивирующем уролитиазе с использованием баз данных, таких как PubMed, Embase, Cochrane Library, Web of Science и Google Scholar. Включены исследования, опубликованные в период с 2010 по 2024 год на английском, русском и казахском языках. Поиск был сосредоточен на терминах, связанных с уролитиазом, рецидивами, профилактикой, диетотерапией, фармакотерапией и изменениями образа жизни. Были выбраны клинические исследования, РКИ, систематические обзоры и мета-анализы. Также использовался метод отслеживания цитат для поиска дополнительных релевантных источников.

Основные стратегии метафилактики уролитиаза включают повышение потребления жидкости, коррекцию диеты и медикаментозное лечение. Потребление не менее 2,5 литров воды в день снижает концентрацию солей в моче, уменьшая риск камнеобразования. Фармакотерапия с использованием тиазидов, цитратов и аллопуринола доказала эффективность в снижении частоты рецидивов. Современные технологии, включая носимые устройства и 3D-изображения, помогают в мониторинге состояния пациентов и обеспечивают более точное лечение.

Метафилактика уролитиаза представляет собой комплексный подход, основанный на изменении образа жизни, фармакотерапии и применении новых технологий. Персонализированные стратегии, включая поддержание высокого уровня потребления жидкости, изменения в диете и регулярный мониторинг, доказали свою эффективность в снижении частоты рецидивов камней в почках. Технологические достижения, такие как

носимые устройства и телемедицина, обещают дальнейшее улучшение результатов лечения и повышение приверженности пациентов к профилактическим мерам.

Ключевые слова: уролитиаз, камни в почках, рецидив, метафилактика, диетическая терапия, фармакотерапия и изменения образа жизни.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj008

Training ABA Therapy Specialists: Global Evidence and the Kazakhstan Context

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Received: 12.05.2025
Accepted: 29.08.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj008.

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Abstract

This article reviews recent evidence on effective training models for Applied Behavior Analysis (ABA) specialists, comparing traditional, blended, and telehealth-based approaches. The analysis highlights that competency-based training with structured supervision ensures high-quality professional preparation. Traditional in-person training remains the gold standard for skill acquisition, while blended and telehealth models increase accessibility and sustainability—particularly relevant for Kazakhstan, where a shortage of qualified specialists persists. Implementing blended learning and tele-supervision could enhance the national capacity to deliver evidence-based behavioral interventions and promote inclusive education. The study underscores the importance of establishing national standards, certification systems, and academic collaboration to develop a sustainable ABA training framework in Kazakhstan.

Key words: applied behavior analysis (ABA), professional training, blended learning, telehealth supervision, competency-based education, inclusive education, Kazakhstan, autism spectrum disorder (ASD).

1. Introduction

In the last decade the prevalence of children with developmental disorders, particularly Autism Spectrum Disorder (ASD), has been steadily increasing worldwide. According to the World Health Organization (2023), approximately one in every 100 children has ASD. People with ASD characterized by difficulties in social interaction, communication and patterns of behavior that may differ from typical development. As a result, these individuals, particularly children, face various challenges in adaptation to and integration within social environments. This situation highlights the urgent need for well-trained professionals capable of providing evidence-based interventions to support these children and their families. One of the most effective and scientifically validated approaches is Applied Behavior Analysis (ABA) therapy — a method that focuses on understanding and improving socially significant behaviors through systematic observation, assessment, and reinforcement strategies (Heward, Heron, Cooper, & Scarlett, 2015). ABA therapy designed in way that allows a specialist to meticulously collect the data about each child, assess their knowledge and skills to create an individualized study plan tailored to child's specific needs and continuously evaluate their progress. However, without proper training, interventions may be ineffective or even counterproductive (Leaf et al., 2016).

Although Applied Behavior Analysis has demonstrated substantial effectiveness, many countries continue to face a significant shortage of qualified specialists (Leaf et al., 2016; Maglione, Gans, Das, Timbie, & Kasari, 2012). Kazakhstan, the largest country of Central Asia, is also affected by this issue. While Ministry of Health of Kazakhstan recommends ABA therapy as a non-medical intervention, it is primarily offered through private practices, making it unaffordable for many families. The limited availability of trained professionals not only restricts access to high-quality care but also hinders the inclusion of children with special educational needs in mainstream educational settings(Parsons, Yuill, Brosnan, & Good, 2015).

In Kazakhstan, despite the gradual development of inclusive policies, access to behavioural therapy remains limited. According to national data, more than 203,000 children are registered as requiring special educational conditions, with approximately 16,700 showing communication and social interaction difficulties typical of ASD (Mambetalina et al. 2022). Experts note that these numbers likely underestimate the true prevalence of autism due to diagnostic limitations and the scarcity of trained professionals, especially outside major cities. Despite the governmental support of inclusive education, an absence of standardised ABA certification and structured specialist training remains a major obstacle in implementing universal access to inclusive education in Kazakhstan. In this context, the presence of civic initiatives such as the Bolashak Foundation, which advocates for the creation of equal opportunities and increasing accessibility for children and adults with special educational needs, is vital. This community-based model demonstrates how public engagement can compensate for institutional gaps and promote the integration of ABA practices into Kazakhstan's educational environment (Mambetalina et al. 2022).

In response to the increasing need for trained ABA specialists in educational settings, ensuring the inclusion of all children within the social environment is essential. Training programs for ABA professionals should encompass both theoretical instruction and supervised practical experience. Such an approach ensures that practitioners not only comprehend the scientific foundations of behavioural interventions but also apply these methods ethically and effectively in a real-world context. (Hollins, Morris, & Li, 2023) The following literature review synthesises recent evidence on training models for ABA specialists, comparing the effectiveness of traditional, blended, and telehealth-based approaches, and situates these findings within the current educational and healthcare context of Kazakhstan.

2. Methodology

The systematic literature review followed a structured approach to ensure comprehensive coverage of relevant research papers. The aim of this research was to answer the main research question:

Which training interventions are most effective for developing the competencies of ABA specialists?

Information sources

To answer the research question a relevant publications were identified using the following keywords: *"Applied Behaviour Analysis training," "ABA specialist education," "behaviour analyst supervision* through major scientific databases, such as **PubMed**, **Scopus**, and **Google Scholar**. Reference lists of included studies and relevant review papers were also examined to identify additional sources.

Eligibility criteria

The review included research publications in the English language related to training models or educational strategies for ABA practitioners. Research papers published in the period between 2020 and 2025 in peer-reviewed journals.

The main exclusion criteria were all studies unrelated to ABA specialists' training, or studies that focused on individual outcomes for the trainees without reference to the effectiveness of the training methods.

Data Extraction and Analysis

All selected research papers were examined to identify training methods (traditional in-person, blended, or telehealth), instructional approach (e.g., Behaviour Skills Training, competency-based frameworks), methods of progress assessment and overall outcome of the training. Studies were divided related to the training model, and findings were grouped thematically to compare effectiveness, accessibility, and contextual feasibility.

3. Results

1. Traditional In-Person Training Models

In-person training has long been the traditional method of ABA professional education. This type of program is typically conducted in classroom settings, where teachers deliver evidence-based lectures and use case reports to illustrate key concepts of the subject. Empirical studies consistently show that direct, face-to-face supervision leads to improved skill acquisition, deepens students' understanding of course materials, and strengthens their professional confidence (Kranak, Andzik, Jones, & Hall, 2023; Vazquez, Lechago, & McCarville, 2024).

A systematic review by Kranak et al. (2023) stated that in-person supervision based on Behaviour Skills Training (BST)—which includes instruction, modelling, rehearsal, and feedback—produces measurable improvements in trainees' practical competence(Kranak et al., 2023).

2. Blended Learning Approaches

Blended learning, which combines online theoretical coursework with in-person practice in the field under the guidance of a local supervisor, has been recommended as an optimal solution for continuous access to ABA training without compromising quality. This method was especially useful during the COVID-19 period. (Ninci et al., 2021) The Behaviour Analyst Certification Board (BACB, 2024) supports blended models that meet competency and supervision standards.

A systematic review by Koldas (Koldas, 2025) found that outcomes of blended learning programs can provide the same level of cognitive learning outcomes compared to traditional programs. Online ABA therapy

training offers greater flexibility for students, allowing them to engage in active learning, interaction and discussion with peers, and supervised practical activities at a convenient time. Additionally, other research shows that blended programs reduce other barriers, such as logistics and training costs. These factors increase accessibility for students from remote regions.

In practice, blended learning models often rely on competency-based frameworks such as the BACB Task List (5th ed.), ensuring that theoretical instruction aligns with practical competencies (Martin & Shook, 2011). Several studies have shown that consistent feedback and supervision are maintained in higher education and clinical training, blended learning produces comparable to, or even better learning outcomes, than those of fully in-person models (Lockey, Bland, Stephenson, Bray, & Astin, 2022; Vallée, Blacher, Cariou, & Sorbets, 2020).

3. Telehealth and Remote Supervision Models

Telehealth-based training and supervision became an essential part of global ABA education during the COVID-19 pandemic. These models utilise video conferencing, digital feedback tools, and virtual classrooms to deliver instruction and observe practicum sessions remotely (Batton, Kaplan, Ellis, Schmidt, & Nudelman, 2022; Sipila-Thomas & Brodhead, 2024).

Telehealth supervision improves accessibility in remote and underserved areas. Several reports highlighted that telehealth-based training can achieve similar learner satisfaction and knowledge gains compared to in-person training, with added flexibility. (Du, Guo, & Xu, 2024; Neely, Tsami, Graber, & Lerman, 2022) However, technological barriers remain a major challenge, limiting opportunities for hands-on interaction and real-time feedback (Sipila-Thomas & Brodhead, 2024).

Hybrid tele-supervision approaches that integrate video review with live online feedback have proven effectiveness in training and maintaining the quality of supervision while addressing access limitations (Kranak et al., 2023). Telehealth models are particularly relevant for Kazakhstan and Central Asia, where the shortage of supervisors and geographical distances hinder the establishment of traditional in-person programs.

4. Comparative Effectiveness and Best Practices

Comparative studies highlighted that adherence to evidence-based practice and structured supervision are the strongest indicators of effective ABA specialist training (Kranak et al., 2023). Nonetheless, the selection of an appropriate training format largely depends on contextual factors such as local infrastructure, accessibility, and institutional capacity. The literature converges on several best practices:

Training element	Evidence of effectiveness	Supporting sources
Traditional In-Person Training Models	Ensures standardised skills acquisition Strongest effect on practical competence	(Kranak et al., 2023; Vazquez et al., 2024)
Blended Learning Approaches	Effective balance of theory and practice Improved accessibility	(Koldas, 2025; Lockey et al., 2022; Ninci et al., 2021; Vallée et al., 2020)
Telehealth and Remote Supervision Models	Essential for local sustainability Improved accessibility	(Batton et al., 2022; Du et al., 2024; Neely et al., 2022; Sipila-Thomas & Brodhead, 2024)

4. Discussion

The results of this review emphasize a growing understanding that ABA specialist training should be grounded in evidence-based approaches and adapted to the local context. Traditional in-person education continues to serve as the most effective model for direct supervision and immediate feedback. Nevertheless, this

approach demands considerable resources, including supervisor time, travel, and access to appropriate client cases. In many low-resource settings, including Kazakhstan, the limited number of qualified supervisors and practicum opportunities poses additional challenges.

In Kazakhstan, where inclusive education is still developing, the introduction of blended and telehealth-supported training formats could help overcome regional inequalities and the shortage of resources. These methods would also create opportunities for collaboration between local universities and international experts, supporting the formation of a sustainable national network of trainers and supervisors.

Another promising direction involves integrating ABA principles into psychology, pedagogy, and medical education. Introducing ABA-related competencies into undergraduate curricula would help increase the number of specialists equipped with practical, evidence-based behavioral management skills.

However, beyond curriculum development, long-term success requires institutional commitment, continuous professional growth, and formal recognition of the ABA profession. Establishing national standards of competency and a certification system, endorsed by the Ministries of Education and Health, would ensure the quality and sustainability of ABA practice across the country.

Future studies should explore the results of pilot ABA training initiatives in Kazakhstan, particularly evaluating how blended and telehealth models influence practitioner skills and outcomes for children. Evidence from such evaluations would help inform educational policy and guide resource allocation aimed at supporting inclusive education.

5. Conclusion

High-quality training of ABA specialists plays a crucial role in ensuring effective behavioral support for individuals with developmental disorders. Research shows that competency-based programs with structured supervision—whether delivered in person, through blended learning, or via telehealth—can prepare practitioners who are both skilled and ethical in their professional practice.

For Kazakhstan and other countries in Central Asia, blended and telehealth formats are particularly valuable, as access to trained professionals is still limited. Prioritizing supervisor preparation, adapting and translating educational materials, and developing national systems for accreditation will help maintain the scientific quality of ABA training while making it relevant to local needs.

Establishing a sustainable educational framework for ABA professionals will not only improve the quality of therapeutic services but also promote broader inclusion of children with special educational needs in society.

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АВА-терапия мамандарын даярлау: Жаһандық тәжірибе және Қазақстан контексті

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Түйіндеме

Бұл мақалада қолданбалы мінез-құлық талдауы (Applied Behavior Analysis, ABA) мамандарын даярлаудың тиімді модельдері қарастырылады. Дәстүрлі, аралас (blended) және теледенсаулық (telehealth) форматтарының тиімділігі салыстырмалы түрде талданған.

Зерттеу нәтижелері көрсеткендей, құрылымдалған супервизиямен бірге жүргізілетін құзыреттілікке негізделген оқыту жоғары сапалы кәсіби дайындықты қамтамасыз етеді. Дәстүрлі офлайн оқыту ең тиімді болып саналса, аралас және қашықтан оқыту үлгілері қолжетімділікті арттырады және тұрақтылықты қамтамасыз етеді.

Бұл тәсілдер Қазақстан үшін өзекті, себебі елде білікті АВА мамандарының жетіспеушілігі байқалады. Аралас және телесупервизия форматтарын енгізу инклюзивті білім беруді дамытуға және ғылыми негізделген мінез-құлықтық араласуларды жүзеге асыруға мүмкіндік береді. Мақалада ұлттық стандарттар мен сертификаттау жүйесін қалыптастырудың маңыздылығы атап өтіледі.

Түйін сөздер: қолданбалы мінез-құлық талдауы (АВА), кәсіби даярлық, аралас оқыту, телесупервизия, құзыреттілікке негізделген білім, инклюзивті білім, Қазақстан, аутизм спектрінің бұзылысы (АСБ).

Подготовка специалистов по прикладному анализу поведения (АВА-терапии): Мировой опыт и казахстанский контекст

Омарғали А.Е. [1], Уразова У.М. [2], Ураз Р.М. [3], Әлбілекова С.Т. [4], Каниева Н.А. [5], Мамбеталина А.С. [6], Шаймуханов А.С. [7]

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Резюме

В статье представлен обзор современных моделей подготовки специалистов по прикладному анализу поведения (Applied Behavior Analysis, ABA) с сравнением традиционного, смешанного (blended) и телемедицина (telehealth) форматов обучения.

Анализ показывает, что программы, основанные на компетентностном подходе и структурированной рукаводстве, обеспечивают высокий уровень профессиональной подготовки. Традиционные очные программы способствуют лучшему усвоению практических навыков, тогда как смешанные и дистанционные форматы повышают доступность и устойчивость обучения.

Эти подходы особенно актуальны для Казахстана, где сохраняется дефицит квалифицированных специалистов. Внедрение смешанных и дистанционных -моделей может способствовать развитию инклюзивного образования и расширению применения научно обоснованных поведенческих интервенций. Подчеркивается необходимость создания национальных стандартов, системы сертификации и академического сотрудничества для устойчивого развития подготовки ABA специалистов в Казахстане.

Ключевые слова: прикладной анализ поведения (ABA), профессиональная подготовка, смешанное обучение, телесупервизия, компетентностное образование, инклюзивное образование, Казахстан, расстройства аутистического спектра (РАС).

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj009

Bibliometric analysis of publications on the use of herbal medicines for the treatment of type 2 diabetes (2004–2025)

Received: 5.05.2025
Accepted: 25.07.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj009.

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Abstract

The search for new hypoglycemic agents for the prevention and treatment of type 2 diabetes is driven by the severe burden of this disease on the global population. Type 2 diabetes affects over 500 million adults worldwide and is characterized by a steady increase, despite the impressive arsenal of synthetic hypoglycemic drugs that target various stages of diabetes pathogenesis. Interest in natural complex compounds found in medicinal plants is currently growing. This bibliometric analysis aims to examine the results of studies on the hypoglycemic potential of herbal medicines in the treatment of patients with type 2 diabetes. Data were extracted from the open-access PabMed database using an inclusive search strategy. The analysis included 379 relevant studies published in 180 different sources, involving 1,804 authors. The results show a marked increase in research on the efficacy of herbal remedies, indicating a growing interest in new sources of non-drug approaches to diabetes. Bradford's Law identified 13 key journals that played a significant role in disseminating research in this area, with Medicine emerging as the most prolific. The United States and China were particularly strong in collaborative research. The China Academy of Chinese Medical Sciences, Beijing University of Chinese Medicine, and the Hospital of Chengdu University of Traditional Chinese Medicine were the most productive institutions, and Tong X. and Zhang Y. were the lead authors. A chronological keyword analysis highlighted the significance of terms such

as "Humans, female, middle-aged, male, diabetes mellitus type 2, drug therapy." Overall, this study sheds light on the global landscape of research on the use of herbal remedies in patients with type 2 diabetes. The information obtained from this analysis is important for determining future research priorities and collaborative efforts in finding effective drugs or improving treatment outcomes for type 2 diabetes and its complications. However, the study acknowledges the limitations of using a single publication database and recommends that future studies include data from other sources.

Keywords: type 2 diabetes, herbal remedies, herbs, bibliometrics, co-occurrence, herbal.

1. Introduction

Diabetes mellitus (DM) is currently recognized as one of the most significant noncommunicable epidemics globally, attracting the attention of the United Nations (UN) and the healthcare systems of various countries. The disease is characterized by a steadily increasing prevalence and poses a serious threat to public health due to the high incidence of early disability and mortality associated with vascular complications [1].

According to the International Diabetes Federation (IDF), the number of people aged 20–79 years with DM has reached 537 million. By 2045, this number is projected to almost double, reaching 783 million people, representing a 46% increase [2–4].

The search for herbal remedies for the treatment of diabetes is of great scientific and practical importance. Despite advances in modern pharmacotherapy, a complete cure for diabetes remains elusive, and existing medications are often associated with side effects and high costs. This makes the search for natural alternatives with effective and safe hypoglycemic effects relevant [5–7].

Plant sources are a rich reservoir of biologically active compounds—flavonoids, alkaloids, terpenoids, saponins, and polyphenols—that can regulate blood glucose levels, increase tissue sensitivity to insulin, protect pancreatic β-cells, and reduce oxidative stress. They can exert a multicomponent effect, combining antioxidant, anti-inflammatory, lipid-lowering, and nephroprotective effects, which is particularly important in the complex treatment of diabetes and its complications [8–11].

Thus, the study and implementation of herbal remedies in the treatment of diabetes mellitus represents a promising direction that can expand therapeutic options, improve its safety and accessibility, and facilitate the development of a personalized approach to the treatment of this disease.

Bibliometric analysis is an effective method for the quantitative evaluation of scientific publications, allowing researchers to track the development of specific scientific areas. This approach is based on the application of mathematical and statistical tools to analyze the growth dynamics, productivity, and overall trends of publication activity on a specific topic [12,13].

In medical science, bibliometric analysis is particularly important, as it helps identify key research trends, leading countries and institutions, and points to areas requiring further development. This study can serve as an important basis for future comparative studies and analytical reviews. Its primary goal is to identify key trends and achievements in this field, as well as to identify promising areas for further research and improvement.

2. Materials and Methods

To ensure high-quality research data, journals were searched in the internationally recognized PabMed database (pubmed.ncbi.nlm.nih.gov) in September 2025 using the keywords: (Herbal AND type 2 diabetes mellitus). Bibliometric analysis was conducted using the Bibliometrix package for R[14]. The number of publications was taken into account to identify the most productive journals, and Bradford's law was applied to identify key journals that significantly contribute to citations in the field.

3. Results

3.1 General Description of Included Studies

Figure 1 shows the flowchart of the literature search and study selection. A total of 433 articles were identified and screened by title and abstract in accordance with the inclusion criteria for review and research articles in English published over the past 20 years (2004–2024). A total of 379 articles were selected. To visualize the data extraction process, Figure 1 shows a PRISMA flow chart[15] describing the selection process.

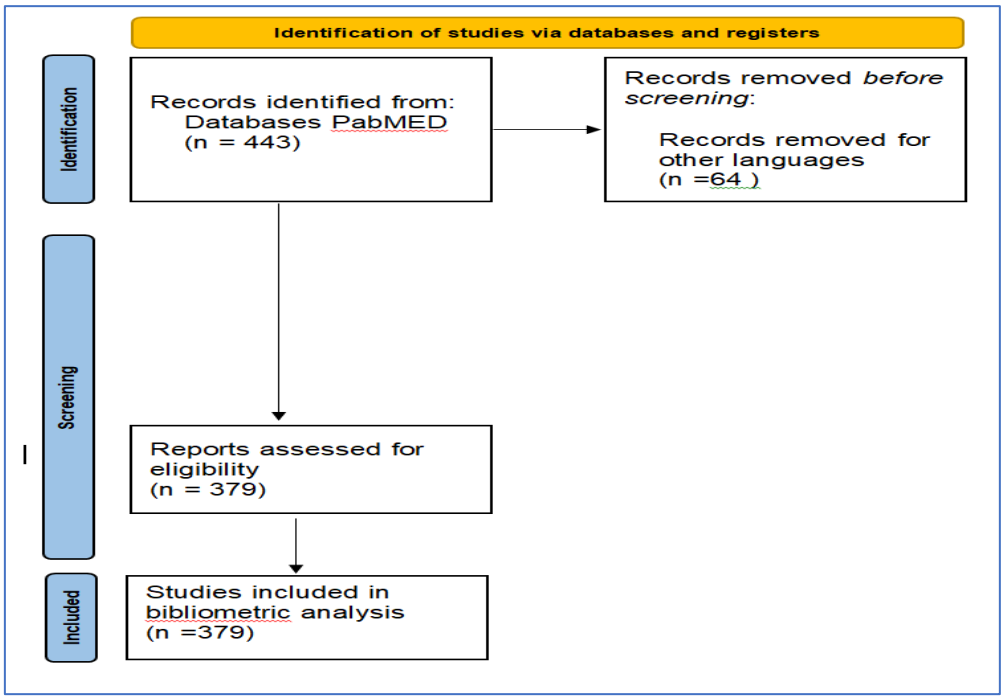

Figure 1 - Flowchart of the publication screening process using PRISMA

3.2 Publication trends by year

Figure 2 shows the publication trends by year. Before 2010, very few publications were found on the use of plants for type 2 diabetes. From 2004 to 2010, the number of publications did not exceed 10. Between 2017 and 2024, the number of published articles on the effects of herbal remedies on diabetes increased significantly. During this period, the number of publications varied, but the overall trend was relatively stable: the number of publications increased year after year, reaching a peak of 38 publications in 2022.

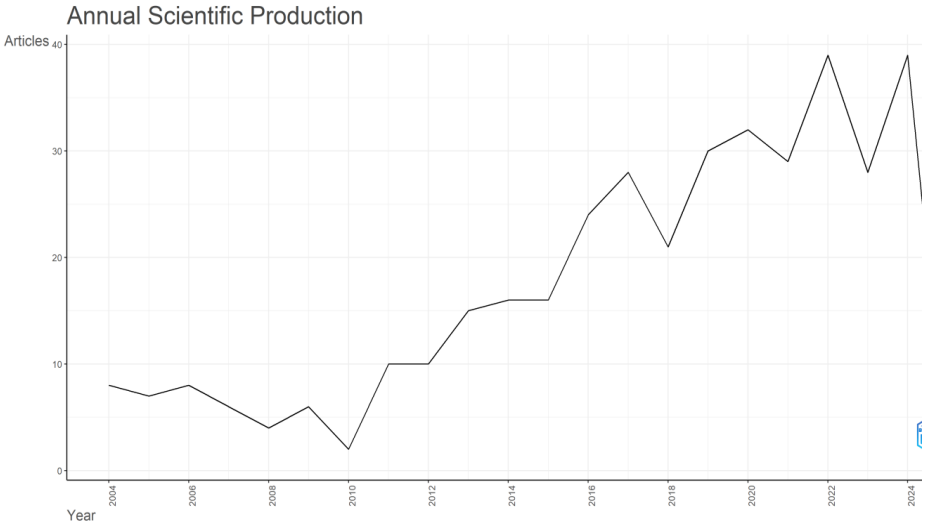

Figure 2 - Publication year trends for herbal medicine research in type 2 diabetes

3.3 Key Authors and Author Group

In this bibliometric analysis, we counted the first authors of all included articles and their corresponding number of publications on herbal medicines for type 2 diabetes (Figure 3). After counting, authors who published eight or more articles were defined as key authors in this topic area. The results of this study showed that 10 key authors published a total of 109 articles, representing 6% (109/1800) of all included articles. This percentage falls far short of Price's requirement for a key author group. Thus, a key author group in the field of herbal medicine research in type 2 diabetes was not identified.

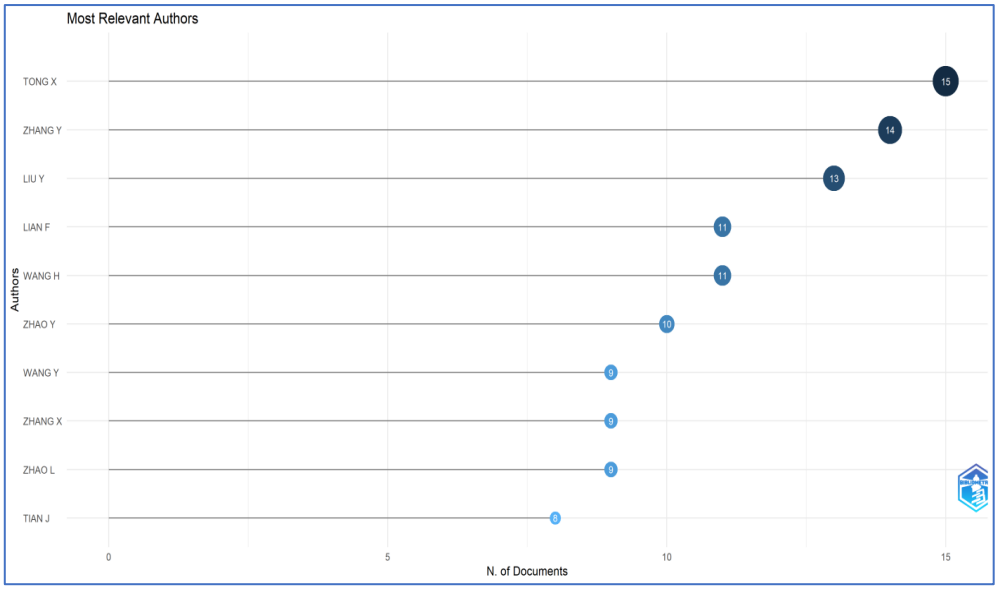

Figure 3(a) - Most productive authors: ten most significant authors and their contribution to the study of herbal remedies for the treatment of type 2 diabetes (2004–2024)

3.4 Major journals

Using Bradford's law, which describes the distribution of scientific articles among journals, we identified ten key journals of greatest interest to researchers in this field (Figure 4). According to this law, these journals form the core of publications on the effectiveness of herbal remedies for type 2 diabetes. The analysis showed (Figure 5) that the journal "Medicine" is the most productive, with 14 articles published. Among the key publications on this topic, the journals "Molecules" stand out - 13 articles, "Frontiers in Pharmacology" - and "Journal of Ethnopharmacology" - 12 articles each, which publish a significant number of studies devoted to natural compounds and their pharmacological effects.

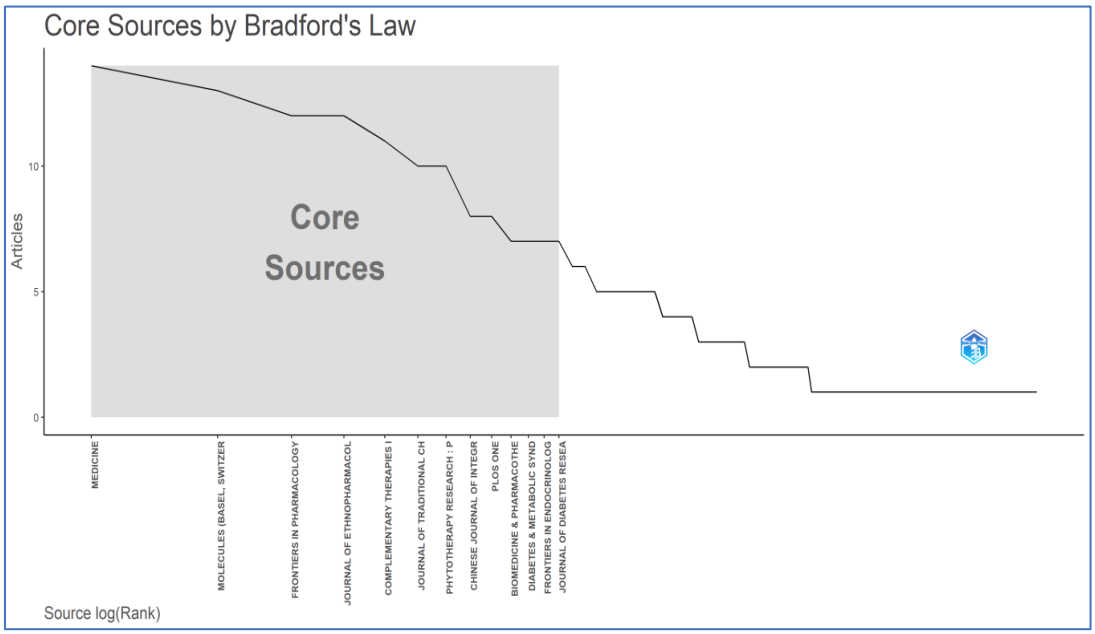

Figure 4 - Bradford's Law Graph - Main Journals

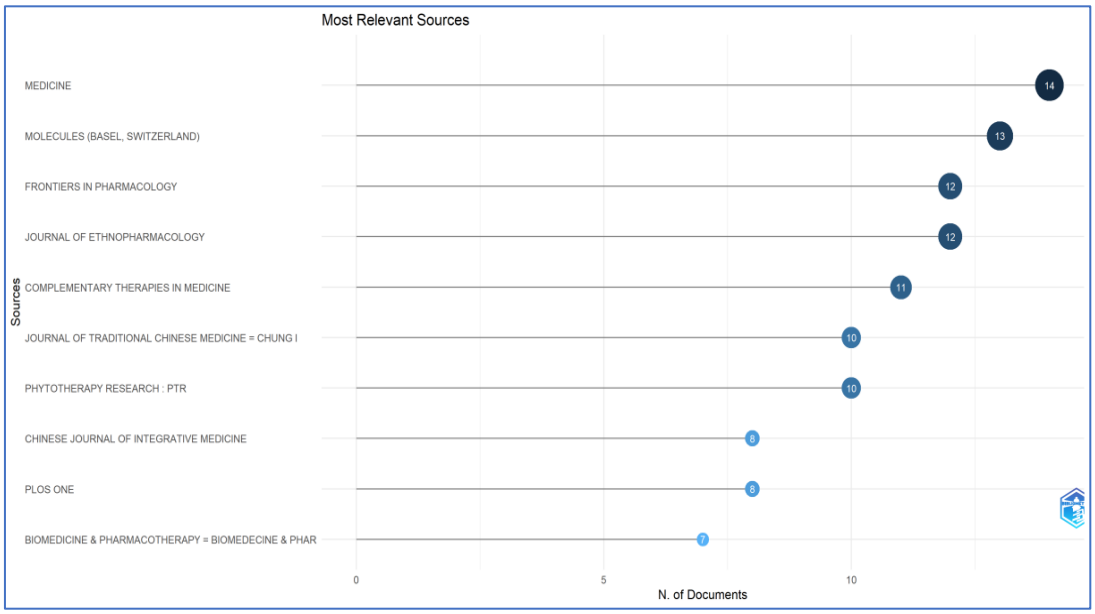

Figure 5 - Top 10 most cited journals

3.5 Key Organizations and Countries, Their Collaborations the most productive organizations by number of publications in the field under study.

The diagram shows the distribution of the number of articles by the authors' primary affiliations. The leading institutions are the China Academy of Chinese Medical Sciences (105 articles), Beijing University of Chinese Medicine (65), and the Hospital of Chengdu University of Traditional Chinese Medicine (57). Organizations in China make the largest contribution to publication activity, indicating their leading role in scientific research in this area (Figure 6).

Figure 7 shows the geographic distribution and areas of collaboration between countries involved in publications on the topic under study. The most intensive collaboration is observed in China, which is highlighted in the darkest shade of blue, indicating its leading position in the number of publications and international collaborations. China actively collaborates with the United States, Canada, Iran, Australia, and European countries. The light blue areas represent countries with less publication activity but engaged in international collaborations.

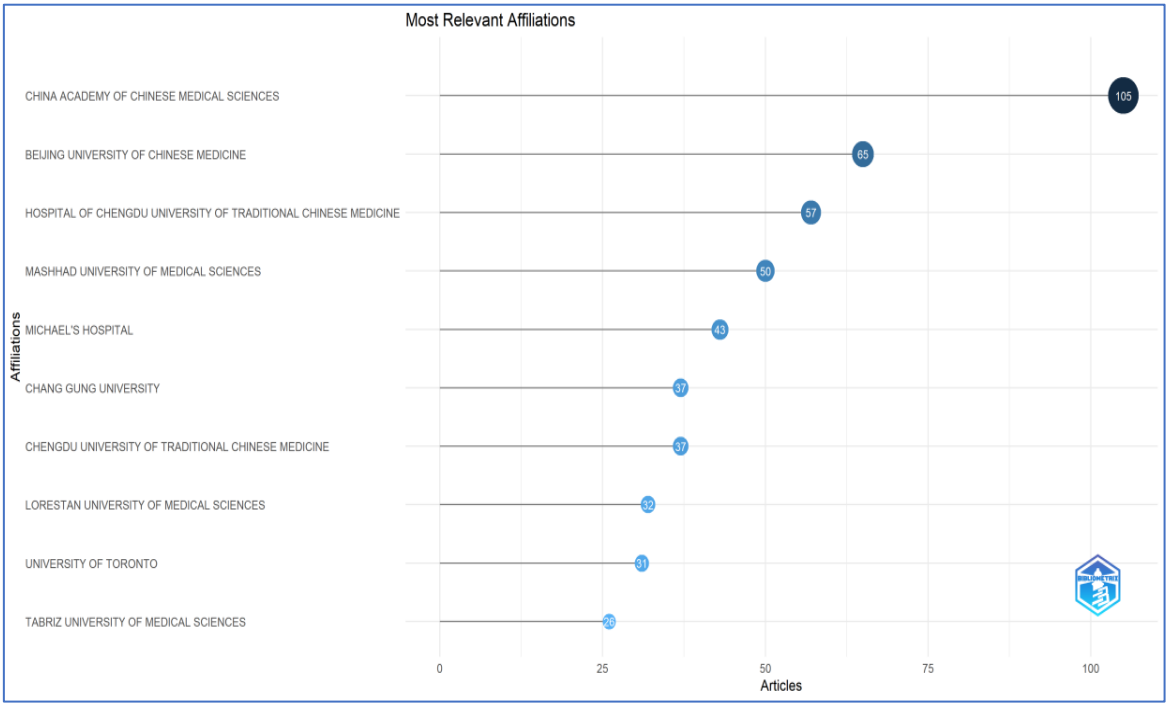

Figure 6 - The most productive organizations in the study area

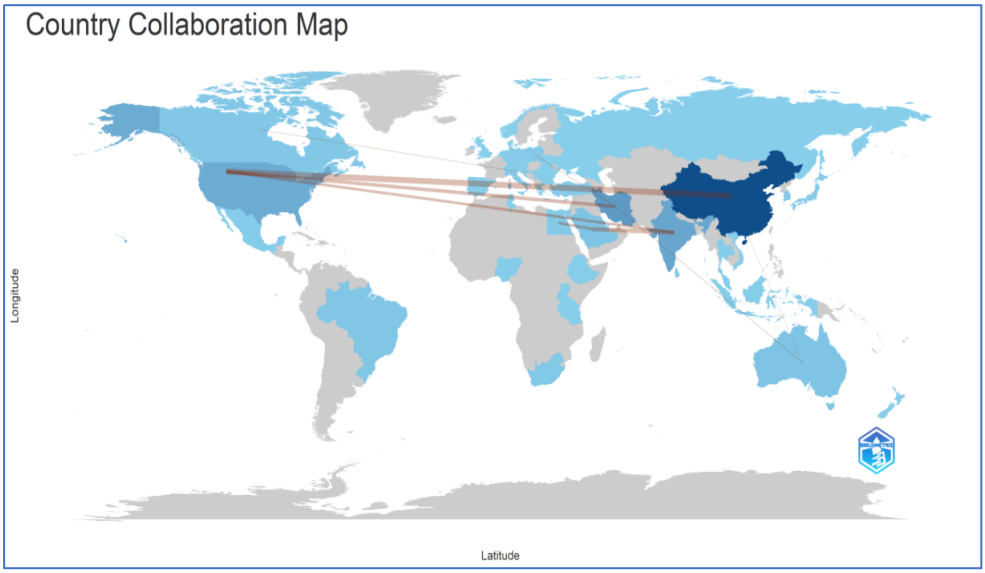

Figure 7 - Country Collaboration Map

In summary, this study analyzed the results of global research on the efficacy and use of herbal remedies in patients with type 2 diabetes over the past 20 years. Leading journals, influential articles, and collaborative projects between institutions, authors, and countries were identified. The results provide valuable insights into the research landscape and point to potential directions for future research.

4. Discussion

In recent years, bibliometric analysis and scientific mapping have rapidly developed, driven by growing interest among researchers in systematizing and evaluating scientific advances in herbal medicine and diabetology [16]. Using a bibliometric approach allows us to identify key trends in the study of herbal remedies for diabetes, identify the most productive authors, countries, and scientific organizations, and assess the impact of the most cited publications. This analysis contributes to a deeper understanding of the intellectual landscape of this field and helps identify promising areas for further research [17, 18]. Recent studies have shown that high consumption of "healthy" plant-based foods is associated with a lower risk of hyperglycemia, while "unhealthy" plant-based diets (high in processed plant foods) may actually increase the risk of diabetes [19].

A bibliometric analysis revealed that scientific interest in studying herbal remedies for type 2 diabetes has increased significantly over the past two decades. Until 2010, publication activity in this area remained extremely low, likely due to the limited clinical and experimental data on the mechanisms of action of herbal remedies. Since 2017, there has been a significant increase in the number of publications, peaking in 2022. This trend reflects a global trend toward searching for alternative and adjuvant approaches to diabetes treatment based on the principles of evidence-based herbal medicine and integrative medicine. The absence of a distinct "core group of authors" according to the Price criterion indicates the fragmentation of the research field and the absence of stable scientific schools specializing exclusively in herbal remedies for T2DM. This may be a consequence of the multidisciplinary nature of the topic, combining pharmacology, endocrinology, botany, and biochemistry. At the same time, the presence of ten of the most productive authors indicates the formation of an active scientific community, around which closer collaborations may develop in the future. An analysis of leading journals showed that the main core of publications is concentrated in publications focused on the pharmacology of natural compounds and traditional medicine: Medicine,

Molecules, Frontiers in Pharmacology, and the Journal of Ethnopharmacology. This confirms that research in this area is predominantly conducted in the context of assessing the biological activity and mechanism of action of natural compounds. A recent review conducted in 2023 shows that dietary therapy research encompasses a wide range of interventions, and not just individual herbal remedies" [20, 21]. In terms of research geography, China's dominance is clear, consistent with the high degree of institutional support and traditionally strong scientific schools in the field of Chinese medicine. Leading universities and academies in China (China Academy of Chinese Medical Sciences, Beijing University of Chinese Medicine, Chengdu University of Traditional Chinese Medicine) form the core of publication activity. China's expanding international collaboration with the United States, Iran, Canada, and European countries indicates the globalization of herbal medicine research and a growing interest in interdisciplinary approaches. Overall, the obtained results demonstrate the rapid development of research aimed at identifying new plant compounds with hypoglycemic activity and studying their pharmacological properties. However, the fragmented nature of research relationships, the limited number of clinical trials, and the heterogeneity of methodological approaches indicate the need for standardization of research, increased international collaboration, and the integration of experimental and clinical data. This bibliometric study has several limitations that should be considered when interpreting the results. First, the search and selection of publications was conducted exclusively in the PubMed database, which may have resulted in incomplete coverage of the literature on the topic. As a result, some relevant publications presented in other sources (e.g., Scopus, Web of Science, Embase, Dimensions) may have been missed. This limits the comprehensiveness of the analysis and may, to a certain extent, bias the results toward journals indexed primarily in PubMed. Second, due to differences in journal indexing and metadata structuring, some publications may have been duplicated or incompletely captured when visualized in VOSviewer. Despite data verification measures taken, such errors cannot be completely eliminated. Nevertheless, using the PubMed database ensures high scientific reliability and standardization of the data, making the obtained results a reliable basis for subsequent comparative and multicenter bibliometric analyses.

5. Conclusions

Thus, the bibliometric analysis allowed us to identify key trends, leading research centers, and key development areas in the field. In the future, it is advisable to increase attention to the clinical aspects of the use of herbal remedies, as well as to assessing their safety, interactions with drugs and cost-effectiveness in the treatment of type 2 diabetes mellitus.

Conflicts of interest. None to declare.

Financing. None.

Author contributions. Conceptualization - A.S.; methodology – A.S.; writing (original draft preparation) – A.S., A.T., A.Z; writing (review and edition) – A.S. All authors have read, agreed to release version of a manuscript and signed the Author's right transfer form.

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2 түрлі қант диабетін емдеуге арналған шөптік дәрілерді қолдану туралы басылымдарды библиометриялық талдау (2004–2025 жж.)

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Түйіндеме

2 типті қант диабетінің алдын алу және емдеу үшін жаңа гипогликемиялық агенттерді іздеу бұл аурудың әлемдік халыққа түсетін ауыр жүктемесімен байланысты. 2 типті қант диабеті бүкіл әлемде 500 миллионнан астам ересек адамға әсер етеді және қант диабеті патогенезінің әртүрлі кезеңдерін нысанаға алатын синтетикалық гипогликемиялық препараттардың әсерлі арсеналына қарамастан, тұрақты өсумен сипатталады. Дәрілік өсімдіктерде кездесетін табиғи кешенді қосылыстарға қызығушылық қазіргі уақытта артып келеді. Бұл библиометриялық талдау 2 типті қант диабетімен ауыратын науқастарды емдеуде шөптік дәрілердің гипогликемиялық әлеуетін зерттеу нәтижелерін зерттеуге бағытталған. Деректер ашық қолжетімді PabMed дерекқорынан инклюзивті іздеу стратегиясын қолдана отырып алынды. Талдауға 180 түрлі дереккөзде жарияланған 379 тиісті зерттеу кірді, оған 1804 автор қатысты. Нәтижелер шөптік дәрілердің тиімділігі бойынша зерттеулердің айтарлықтай өскенін көрсетеді, бұл қант диабетін емдеудің дәрілік емес тәсілдерінің жаңа көздеріне қызығушылықтың артуын көрсетеді. Брэдфорд заңы осы саладағы зерттеулерді таратуда маңызды рөл атқарған 13 негізгі журналды анықтады, оның ішінде «Медицина» ең көп таралған болып шықты. Америка Құрама Штаттары мен Қытай бірлескен зерттеулерде ерекше күшті болды. Қытай медициналық ғылымдары академиясы, Пекин медицина университеті және Чэнду дәстүрлі қытай медицина университетінің ауруханасы ең өнімді мекемелер болды, ал Тонг Х. мен Чжан Ү. жетекші авторлар болды. Хронологиялық кілт сөздерді талдауда «Адамдар, әйелдер, орта жастағы, ер адамдар, 2 типті қант диабеті, дәрілік терапия» сияқты терминдердің маңыздылығын атап өтті. Жалпы алғанда, бұл зерттеу 2 типті қант диабетімен ауыратын науқастарда шөптік дәрілерді қолдану бойынша зерттеулердің жаһандық ландшафтына жарық түсіреді. Бұл талдаудан алынған ақпарат болашақ зерттеу басымдықтарын және тиімді дәрілерді табу немесе 2 типті қант диабеті мен оның асқынуларын емдеу нәтижелерін жақсарту бойынша бірлескен күш-жігерді анықтау үшін

маңызды. Дегенмен, зерттеу бірыңғай басылым дерекқорын пайдаланудың шектеулерін мойындайды және болашақ зерттеулерге басқа көздерден алынған деректерді қосуды ұсынады.

Түйін сөздер: 2 типті қант диабеті, шөптік дәрілер, шөптер, библиометрия, бірге кездесетін, шөптік.

Библиометрический анализ публикаций по использованию растительных препаратов для лечения сахарного диабета 2 типа (2004–2025 гг.)

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Резюме

Поиск новых сахароснижающих препаратов для профилактики и лечения сахарного диабета 2 типа обусловлен тяжелым бременем данного заболевания на население планеты. Сахарный диабет 2 типа поразил более 500 миллионов взрослых людей в мире и характеризуется неуклонным ростом,несмотря на внушительный арсенал синтетических гипогликемических лекарств, воздействующих на различные звенья патогенеза диабета. В настоящее время растет интерес к природным комплексным соединениям в составе лекарственных растений. Этот библиометрический анализ направлен на изучение результатов исследований сахаронижающего потенциала растительных препаратов в лечении пациентов с сахарным диабтом 2 типа. Данные были извлечены из базы данных открытого доступа PabMed с использованием инклюзивной стратегии поиска. Анализ включал 379 соответствующих исследования, опубликованных в 180 различных источниках, с участием 1804 авторов. Результаты показывают заметный рост исследований эффективности растительных препаратов, что указывает на возрастающий интерес к новым источникам немедикаментозного подхода в диабете. Закон Брэдфорда определил 13 основных журналов, которые сыграли важную роль в распространении исследований в этой области, причем «Медицина» оказалась самым плодовитым журналом. Самыми сильными в совместных исследованиях оказались США и Китай. China Academy Of Chinese Medical Sciences, Beijing University Of Chinese Medicine, Hospital Of Chengdu University Of Traditional Chinese Medicine были наиболее продуктивными учреждениями, а Tong X. И Zhang Y. были ведущими авторами. Хронологический анализ ключевых слов подчеркнул значимость таких терминов, как «Humans, female, middle aged, male, diabetes mellitus type 2, drug therapy». В целом, это исследование проливает свет на глобальный ландшафт исследований использования растительных препаратов у пациентов с сахарным диабетом 2 типа. Информация, полученная в результате этого анализа, имеет важное значение для определения будущих приоритетов исследований и совместных усилий в поиске эффективных лекарств или улучшению результатов лечения сахарного диабета 2 типа и его осложнений. Однако в исследовании признаются ограничения, связанные с использованием одной только базы данных публикаций, и рекомендуется в будущие исследования включать данные из других источников.

Ключевые слова: сахарный диабет 2 типа, растительные препараты, травы, Bibliometric, Co-Occurrence, Herbal.

Astana Medical Journal
e2790-1203

https://doi.org/10.54500/2790-1203-2025-5-125-amj010

Анализ распространенности метаболического синдрома и ожирения среди населения г. Алматы

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Received: 24.05.2025
Accepted: 20.08.2025
Published: 31.10.2025

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Citation: Astana Medical Journal, 2025, 125 (5), amj010.

Резюме

По результатам последних исследований в Казахстане около 31,2 % взрослых страдают ожирением, в то время как международные наблюдатели сообщают о 23,5 % случаев ожирения в Казахстане. В Казахстане уровень ожирения среди взрослого населения сопоставим с другими странами Центральной Азии и демонстрирует тенденцию к росту, что подтверждает актуальность таких исследований. Целью настоящей статьи было изучение распространенности метаболического синдрома и ожирения среди населения г. Алматы. В исследовании использовались ретроспективные и проспективные, анонимизированные данные пациентов, полученные из двух источников: Центра спортивной медицины г. Алматы (С) Поликлиники №6 г. Алматы (П). Исследуемый период охватывал 2021–2025 годы. В итоговую выборку вошли

данные 1244 пациентов Центра спортивной медицины и дополнительно 73 пациента из Поликлиники №6, в возрасте от 20 до 70 лет. Для всех обследованных были проанализированы следующие параметры: дата обследования, возраст, пол, рост, масса тела и индекс массы тела (ИМТ). Статистическая обработка и сравнительный анализ проводились с использованием программного обеспечения GraphPad Prism (версия 10.0) и Microsoft Excel 2021. Количество пациентов с ожирением среди спортсменов составило всего 38%, по сравнению с 61% пациентов поликлиники. При этом, среди молодых спортсменов отмечен достаточно высокий процент людей с избыточным весом (38%), причем больше среди мужчин. Среди остального населения женщины страдали ожирением чаще. В связи с чем, необходимы дальнейшие исследования в более старших возрастных группах, с охватом других медицинских центров, с применением более углубленных методов изучения нарушений метаболизма.

Ключевые слова: ожирение, метаболический синдром, спортивная медицина, индекс массы тела.

1. Введение

Распространённость ожирения во всём мире значительно возросла за последние десятилетия, и Всемирная организация здравоохранения (ВОЗ) признала его глобальной эпидемией [1]. Ожирение представляет собой растущую угрозу для здоровья населения во всем мире, и это явление также наблюдается в Казахстане. Термины «избыточный вес» и «ожирение» определяются как аномальное или чрезмерное накопление жира, которое может оказать вредное воздействие на здоровье [2]. Наблюдается рост числа людей с ИМТ 25–30 кг/м², что сопровождается увеличением числа пациентов с диагнозом «эндокринные нарушения» [3].

Согласно данным Национального генетического реестра, ежегодно регистрируется около 30 000 пациентов с эндокринными патологиями, большинство из которых страдают диабетом [4,5]. Пятое национальное исследование в Казахстане показало, что 31,2 % взрослых страдают ожирением, в то время как международные наблюдатели сообщают о 23,5 % случаев ожирения в Казахстане [6,7].

Однако требуется дальнейшее изучение распространенности ожирения, его связи с эндокринными нарушениями, пищевыми привычками и демографическими или географическими особенностями. Несмотря на реализацию широких профилактических программ, направленных на формирование здорового образа жизни и рационального питания, предпринятые меры оказались недостаточными для существенного замедления данной тенденции [2,8,9].

Ожирение рассматривается как сложное, гетерогенное, хроническое и прогрессирующее заболевание, оказывающее значительное влияние на здоровье населения, качество жизни и показатели смертности [9]. Основными подходами к его лечению остаются изменения образа жизни и поведения (коррекция питания, повышение физической активности), однако в большинстве случаев эти меры обеспечивают лишь краткосрочный или ограниченный эффект [10]. В настоящее время наиболее эффективным и доказанным методом лечения ожирения остаётся бариатрическая (метаболическая) хирургия, положительно

влияющая не только на снижение массы тела, но и на состояние сердечно-сосудистой и почечной систем, а также снижающая риск онкологических заболеваний и связанных с ожирением случаев преждевременной смертности [11].

Одновременно достигнут существенный прогресс в разработке и клиническом применении современных фармакологических препаратов для лечения ожирения, эффективность которых в ряде случаев приближается к результатам хирургических вмешательств [12]. Однако, как на глобальном уровне, так и в Казахстане, все доступные терапевтические подходы используются крайне ограниченно, что препятствует эффективному контролю за распространённостью данного заболевания [13,14].

Согласно определению, принятому Всемирной организацией здравоохранения (ВОЗ), ожирение определяется как патологическое накопление жировой ткани, представляющее угрозу для здоровья. Диагноз этого состояния обычно ставится на основании индекса массы тела (ИМТ = вес [кг]/рост² [м²]), при показателе ≥ 30 кг/м², который изначально был разработан для белого населения [15,16]. Несмотря на удобство и широкое использование в скрининге и эпидемиологических исследованиях, ИМТ подвергается критике за неспособность учитывать различия в составе тела между этническими группами [17-19]. Это особенно актуально для Казахстана, где этническое разнообразие населения может влиять на интерпретацию показателей ожирения.

Во всем мире распространенность ожирения среди взрослых достигла эпидемических масштабов: более 890 миллионов взрослых (примерно 13% взрослого населения мира) относятся к категории ожирения. С 1975 года распространенность ожирения значительно возросла, и по прогнозам к 2030 году число взрослых с ИМТ ≥ 30 кг/м² превысит 1 миллиард (18% населения) [9]. Для Казахстана данная проблема имеет особую значимость, учитывая рост урбанизации, изменение структуры питания и снижение физической активности среди детей и взрослых [20].

Международные данные свидетельствуют, что ожирение чаще встречается у женщин, чем у мужчин, и характеризуется значительными региональными различиями [21-23]. В Казахстане уровень ожирения среди взрослого населения сопоставим с другими странами Центральной Азии и демонстрирует тенденцию к росту, что подтверждается результатами национальных и региональных исследований [21,24].

Следует подчеркнуть, что распространённость ожирения также существенно различается в зависимости от социально-экономического статуса, особенно среди женщин. Более половины глобального прироста ИМТ с 1985 по 2017 годы связано с ростом показателей в сельской местности [25]. Казахстан демонстрирует схожие тенденции: наряду с ростом ожирения в крупных городах, в сельских регионах также наблюдается значительное увеличение числа людей с избыточной массой тела, что требует особого внимания к вопросам регионального здравоохранения [25,26].

Таким образом, ожирение в Казахстане следует рассматривать как серьёзную межсекторальную проблему, требующую интеграции усилий системы здравоохранения, образования и социальной политики. Необходим переход от исключительно ИМТ-ориентированных подходов к более точным методам оценки состава тела (например, по жировой массе), что позволит точнее выявлять группы риска и разрабатывать эффективные профилактические и лечебные меры.

Целью настоящей статьи было изучение распространенности метаболического синдрома и ожирения среди населения г. Алматы.

2. Материалы и методы

В исследовании использовались ретроспективные, анонимизированные данные пациентов, полученные из Центра спортивной медицины г. Алматы (С), а также сведения о пациентах Поликлиники №6 г. Алматы (П). Данные пациентов поликлиники были собраны путем анкетирования (онлайн-опроса на платформе Google Forms), включавшего сведения о возрасте, поле, уровне физической активности, образе жизни и пищевых привычках.

Исследуемый период охватывал 2021–2025 годы. Поскольку из Центра спортивной медицины использовались обезличенные ретроспективные данные, получение информированного согласия пациентов не требовалось. Из анализа были исключены лица с дефицитом массы тела (ИМТ < 18,5 кг/м²).

В итоговую выборку вошли данные 1244 пациентов Центра спортивной медицины г. Алматы и 73 пациентов поликлиники № 6 г. Алматы, отобранных случайным образом, без учёта наличия хронических заболеваний. Возраст обследованных составлял от 20 до 70 лет, в выборку вошли пациенты обоего пола. Все пациенты были поделены на две группы: С — Центра спортивной медицины и П — поликлиники.

Для всех обследованных были проанализированы следующие параметры: дата обследования, возраст, пол, рост, масса тела и индекс массы тела (ИМТ).

Оценка степени ожирения проводилась в соответствии с азиатскими критериями ВОЗ, учитывающими повышенные метаболические и кардиоваскулярные риски при относительно меньших значениях индекс массы тела (ИМТ). Для оценки степени ожирения у обследованных пациентов использовался (ИМТ), рассчитываемый по формуле:

ИМТ=масса тела (кг)/рост (м)2

Пациенты были распределены на четыре категории в зависимости от степени ожирения: нормальная масса тела, ожирение I, II и III степени:

Норма: ИМТ от 21,0 до 24,9 кг/м²;

Ожирение I степени: ИМТ от 25,0 до 28,9 кг/м²;

Ожирение II степени: ИМТ от 29,0 до 32,9 кг/м²;

Ожирение III степени: ИМТ ≥ 33,0 кг/м² [12].

В исследование были рандомно отобраны пациенты (общее количество принято за 100%). Для каждого пациента вычислялся ИМТ, после чего проведено распределение по категориям.

Определение долей:

Количество пациентов каждой категории выражалось в процентах от общей численности выборки (100%), что позволило определить долю лиц с нормальной массой тела, избыточным весом и различными степенями ожирения.

Анализ распределения по возрасту и росту проводился для оценки взаимосвязи между степенью ожирения и возрастными характеристиками пациентов:

Для каждой группы рассчитывались средние значения возраста и роста пациентов, а также стандартное отклонение. Сравнение показателей между группами проводилось с использованием параметрических методов статистического анализа.

Для анализа гендерных различий в распределении пациентов по степеням ожирения использовались данные о поле участников, разделённых на группы в зависимости от индекса массы тела (ИМТ).

В каждой группе подсчитывалось абсолютное количество мужчин и женщин, а также рассчитывалась доля мужчин (%) от общего числа участников группы. Для оценки различий в распределении полов между группами проводился сравнительный анализ, с применением критерия χ^2 (хи-квадрат) Пирсона. Этот метод позволял определить, имеются ли статистически значимые различия между группами по половому признаку. Для пациентов поликлиники была применена

аналогичная методика анализа, включающая расчёт индекса массы тела (ИМТ), распределение по степеням ожирения и оценку половых и возрастных характеристик.

Статистическая обработкаоценки индекса массы тела и возраста в различных группах проводилась с использованием программного обеспечения GraphPad Prism (версия 10.0) и Microsoft Excel 2021. Сравнение показателей между группами проводилось при помощи дисперсионного анализа (ANOVA) с последующим тестом Тьюки для множественных сравнений.

Для оценки различий в распространённости ожирения среди мужчин был проведён сравнительный анализ, доля мужчин с различными степенями ожирения рассчитывалась в процентах от общего числа обследованных мужчин в каждой группе. Полученные данные были представлены в виде графического изображения, отражающего разницу в проценте встречаемости ожирения по группам.

3. Результаты исследования

1. Результаты исследования пациентов, обследованных в Центре спортивной медицины г. Алматы.

При оценке степени ожирения из рандомно выбранных пациентов больше всего оказались в группе с нормальным весом - 774 человека (62%). Также было много пациентов из группы ожирения 2 степени - 326 (26%) (Таблица 1).

Таблица 1 - Распределение пациентов по степени ожирения

Группа	**количество пациентов**	**%**
норма	774	62
1 степень	326	26
2 степень	81	7
3 степень	63	5
Всего	1244	100

2. При сравнении распределения по возрасту в группах с разными степенями ожирения не обнаружено статистически значимых различий по росту и возрасту (Таблица 2)

Таблица 2 - Распределение пациентов по возрасту

Группа	Средний Рост	Средний Возраст	Средний Вес
норма	174	20	65
1 степень	177	26	82

2 степень	176	27	95
3 степень	177	27	120

3. При анализе распределение по полу по всем группам наблюдалось преобладание мужчин, за исключением группы с нормальным весом, в которой количество мужчин и женщин было равным (таблица 3). Хотя в проведенных ранее исследованиях было обнаружено превалирование ожирения среди женщин, следует учесть, что в исследование были включены профессиональные спортсмены с преобладанием мышечной массы.

Таблица 3 - Распределение пациентов по полу

Группа	Муж	Жен	% мужчин
норма	378	396	49
1 степень	195	131	60
2 степень	51	30	63
3 степень	36	27	57
Всего	660	584	53

Результаты исследования пациентов из поликлиники

По степени ожирения все пациенты поликлиники распределились следующим образом: всего 46 пациентов, норма у 18 (39%), 3 степень 5(10%), 2 степень - 6 (13%), 1 степень - 16 (34%). То есть, количество пациентов с нормальным весом лишь незначительно превышало количество пациентов с 1 степенью ожирения (Таблица 4).

Таблица 4 - Распределение пациентов по степени ожирения

N	Группа	Количество пациентов, абс.	%
1	норма	46	39
2	1 степень	16	34
3	2 степень	6	13
4	3 степень	5	10
5	Всего	73	100

4. При анализе распределения пациентов по росту в среднем в группах не обнаружено статистически значимых различий (Таблица 5).

Таблица 5 - Распределение пациентов по возрасту

Группа	Средний Рост	Средний Возраст	Средний Вес
норма	164	43	58
1 степень	165	46	74
2 степень	167	44	87
3 степень	164	46	97

5. При анализе распределение по полу по всем группам наблюдалось преобладание женщин, за исключением группы с 2 степенью ожирения, где количество мужчин и женщин было равным (Таблица 6).

Таблица 6 - Распределение пациентов по полу

Группа	Муж	Жен	% мужчин
норма	2	15	13
1 степень	5	11	31
2 степень	3	3	50
3 степень	1	4	20
Всего	11	33	33

Кроме того, нами был изучен индекс массы тела по группам (Рисунок 1-3).

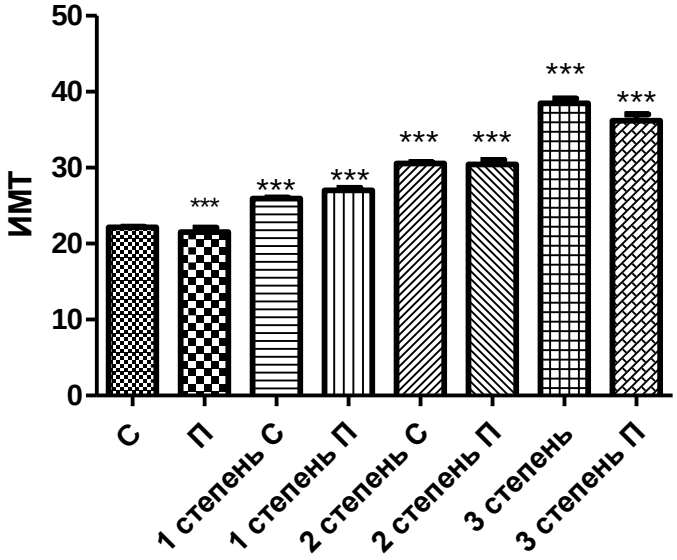

Рисунок 1 - Индекс массы тела в различных группах, С - группа пациентов Центра спортивной медицины, П - группа пациентов поликлиники

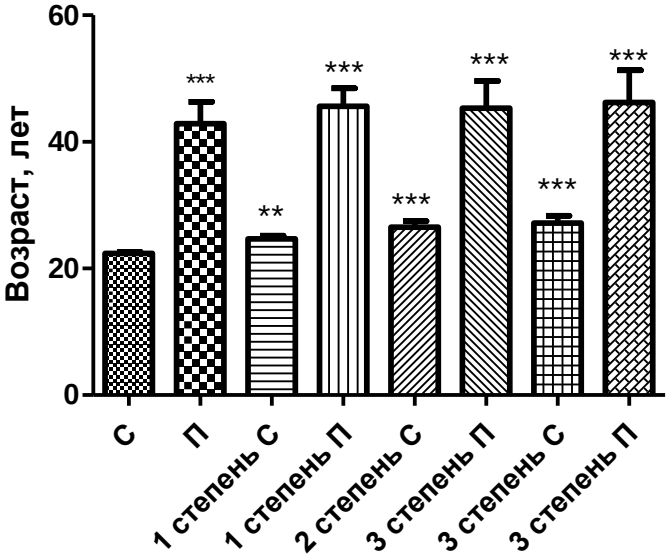

Рисунок 2 - Средний возраст по группам, С - группа пациентов Центра спортивной медицины, П - группа пациентов поликлиники

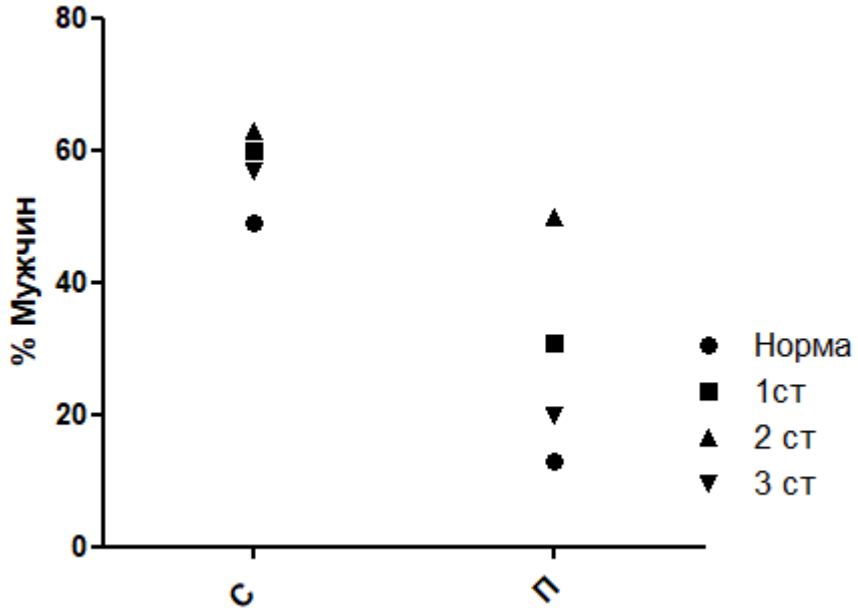

Рисунок 3 - Графическое изображение разницы % встречаемости среди мужчин ожирения.

Как видно на рисунок 3, нормальный ИВТ у людей занимающихся спортом намного выше чем среди людей с ожирением не занимающихся спортом.

4. Обсуждение

Таким образом, нами было проанализировано распределение пациентов разных групп населения по степени метаболических нарушений. Как и в ряде других исследований, количество пациентов с ожирением было больше среди пациентов поликлиники, поскольку эти люди меньше занимались спортом и их возраст был намного выше (в среднем 46 лет), чем у спортсменов (в среднем 25 лет). Кроме того, рост профессиональных спортсменов был заметно выше - 177 см, по сравнению с остальными пациентами поликлиники - 165 см.

Количество пациентов с ожирением среди спортсменов составило всего 38%, по сравнению с 61% пациентов поликлиники. Тем не менее, это намного выше ожидаемых цифр, т.к. предполагается, что интенсивное занятие спортом предупреждает развитие метаболического синдрома и ожирения. Поэтому этот пункт требует дальнейших подробных исследований для разграничения повышенной массы тела, связанной с развитой мускулатурой и повышения массы тела, связанного с метаболическими нарушениями. Также следует принять во внимание, что пациентами Центра спортивной медицины являются бывшие спортсмены и тренеры, у которых спортивная нагрузка гораздо ниже. Поэтому снижение нагрузки при сохранении пищевых привычек также может способствовать набору веса. Очень интересен факт преобладания пациентов с повышенным весом среди мужчин среди спортсменов. Тогда как в большинстве случаев, также как и в группе пациентов поликлиники, повышенный вес больше характерен для лиц женского пола. Вероятнее всего, этот факт можно объяснить повышенной склонностью к наращиванию мускулатуры у мужчин, однако,

данный момент также требует дополнительных исследований.

С учетом вышесказанного, необходимо провести дополнительные исследования на большом количестве пациентов без спортивной истории. Ограничение данного исследования в выборке отражает необходимость в проведении исследования в более старших возрастных группах, с охватом других медицинских центров. Также, будущие исследования должны будут учитывать структуру тела (использовать “умные весы”), т.е. преобладание мышечной, жировой или костной массы, для более точной оценки наличия или отсутствия метаболического синдрома.

5. Выводы

В данном исследовании были получены данные о распространенности ожирения среди лиц занимающихся спортом и остального населения. При этом, среди молодых спортсменов отмечен достаточно высокий процент людей с избыточным весом (38%), причем больше среди мужчин. Среди остального населения женщины страдали ожирением чаще. В связи с чем, необходимы дальнейшие исследования в более старших возрастных группах, с охватом других медицинских центров, с применением более углубленных методов изучения нарушений метаболизма.

Финансирование

Данное исследование финансирует Комитет Науки МОН РК в рамках грантового финансирования 2025-27 (AP26102055 Проектирование системы мониторинга и анализа показателей здоровья пациентов, страдающих метаболическим синдромом, руководитель: Пыркова А.Ю.)

Этические вопросы

Проведение данного исследования было одобрено Локальным Этическим Комитетом КазНУ им.Аль-Фараби, протокол №IRB-A927 от 22.10.2024.

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Алматы қаласы тұрғындары арасында метаболикалық синдром мен семіздіктің таралуын талдау

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Түйіндеме

Соңғы зерттеулердің нәтижелері бойынша Қазақстанда ересек тұрғындардың шамамен 31,2 %-ы семіздікпен ауырады, ал халықаралық деректерде бұл көрсеткіш 23,5 % деп көрсетілген. Қазақстандағы ересек тұрғындар арасындағы семіздік деңгейі Орталық Азияның басқа елдерімен салыстырмалы және өсу үрдісін көрсетеді, бұл мәселенің өзектілігін айқындайды.

Осы мақаланың мақсаты – Алматы қаласы тұрғындары арасында метаболикалық синдром мен семіздіктің таралуын зерттеу. Зерттеу барысында екі дереккөзден алынған пациенттердің ретроспективті және проспективті, анонимдендірілген деректері пайдаланылды: Алматы қалалық Спорттық медицина орталығы (С) және №6 қалалық емхана (П). Зерттеу кезеңі 2021–2025 жылдарды қамтыды.

Қорытынды іріктемеге Спорттық медицина орталығының 1244 және №6 емхананың 73 пациенті енгізілді, олардың жасы 20-дан 70 жасқа дейін болды. Барлық зерттелгендер үшін келесі көрсеткіштер талданды: тексеру күні, жас, жыныс, бой, дене салмағы және дене салмағының индексі (ДСИ). Статистикалық өңдеу мен салыстырмалы талдау GraphPad Prism бағдарламалық жасақтамасы (нұсқа 10.0) және Microsoft Excel 2021 көмегімен жүргізілді.

Спортшылар арасындағы семіздік деңгейі бар-жоғы 38 % болса, емхана пациенттерінде бұл көрсеткіш 61 % болды. Жас спортшылар арасында артық салмақтылардың үлесі (38 %) жоғары, олардың ішінде ерлер басым. Ал жалпы халық арасында семіздік әйелдерде жиірек кездеседі.

Осы нәтижелерге сүйене отырып, метаболизм бұзылыстарын тереңірек зерттеу үшін жасы үлкен топтарды және басқа медициналық орталықтарды қамтитын әрі жетілдірілген зерттеу әдістерін қолданатын қосымша зерттеулер жүргізу қажет.

Түйін сөздер: семіздік, метаболикалық синдром, спорттық медицина, дене салмағының индексі.

Analysis of the Prevalence of Metabolic Syndrome and Obesity Among the Population of Almaty

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Abstract

According to recent research, approximately 31.2% of adults in Kazakhstan are affected by obesity, whereas international observers report a prevalence of 23.5%. The obesity rate among the adult population in Kazakhstan is comparable to that of other Central Asian countries and demonstrates a steady upward trend, underscoring the relevance of further investigation. The objective of the present study was to assess the prevalence of metabolic syndrome and obesity among the population of Almaty. Retrospective and prospective anonymized patient data were obtained from two sources: the Almaty Sports Medicine Center (S) and Polyclinic No. 6 of Almaty (P). The study period covered the years 2021–2025. The final sample included data from 1,244 patients of the Sports Medicine Center and an additional 73 patients from Polyclinic No. 6, aged 20 to 70 years. The following parameters were analyzed for all participants: date of examination, age, sex, height, body weight, and body mass index (BMI). Statistical processing and comparative analysis were performed using GraphPad Prism (version 10.0) and Microsoft Excel 2021. The proportion of patients with obesity among athletes was 38%, compared to 61% among patients from the polyclinic. A relatively high proportion of overweight individuals (38%) was observed among young athletes, particularly among men. In contrast, among the general population, obesity was more prevalent among women. These findings highlight the need for further studies in older age groups, involving additional medical centers and employing more advanced methods for assessing metabolic disorders.

Keywords: obesity, metabolic syndrome, sports medicine, body mass index.

МАЗМҰНЫ

СОДЕРЖАНИЕ

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