Clinical trial research on furagin-induced anaphylactic shock: assessing mechanisms and preventive strategies

Abstract. Background. The study investigates the pressing issue of furagin-induced anaphylactic shock, addressing the immediate need to understand its mechanisms and create preventive strategies. Anaphylactic shock due to furagin, a widely used antimicrobial drug, has raised serious concerns. The goal is to elucidate the underlying mechanisms and risk factors of furagin-induced anaphylactic shock. Materials and methods. This research delves into this critical subject through a controlled longitudinal study on both humans and induced anaphylaxis in rats. Results. Using an advanced blind controlled longitudinal design, the study evaluates allergic reactions in humans and induced anaphylaxis in rats. It also explores the safety, tolerability, and pharmacokinetics of furagin over five days in adult patients. Moreover, the study assesses the efficacy of antihistamine pre-treatment in reducing allergic reactions. Results reveal a dose-dependent trend in allergic reactions in rats, demonstrating the effectiveness of antihistamine pre-treatment in reducing the severity of allergic symptoms. Patients with previous allergies, especially to medications, exhibited increased susceptibility to furagin-induced anaphylactic symptoms. The study underscores the potential for antihistamine pre-treatment as a preventive strategy and contributes to the understanding of allergic responses. This research informs clinical practice by providing insights into risk factors and preventive measures for furagin-induced hypersensitivity, ultimately enhancing patient safety. Conclusions. The study findings hold promise for personalized interventions and advance our understanding of drug-induced hypersensitivity reactions. Keywords: antihistamine medications; drug safety; immune response; IgE antibodies; animal model

Introduction
Clinical trials play a pivotal role in advancing medical knowledge and enhancing patient care by rigorously evaluating the safety and efficacy of various pharmaceutical agents. Among them, furagin, a commonly prescribed antimicrobial drug, has recently garnered attention due to reports of anaphylactic shock occurring as a potential adverse reaction. Anaphylactic shock, a severe and potentially life-threatening allergic reaction, necessitates a comprehensive investigation to understand its mechanisms, identify risk factors, and define preventive strategies. This article delves into the imperative need to undertake clinical trial on furagin-induced anaphylactic shock, aiming to elucidate the underlying issues, expand current knowledge, and contribute to patient well-being. The potential occurrence of anaphylactic shock associated with furagin administration raises significant concerns within the medical community. Anaphylactic shock is a hypersensitive immune response characterized by rapid-onset symptoms such as difficulty breathing, lowered blood pressure, hives, and in severe cases, loss of consciousness. The unpredictability of these reactions makes the prescription of furagin a delicate matter, requiring a comprehensive understanding of the mechanisms that trigger such responses.

Several research have contributed to the understanding of anaphylactic reactions and their associated risk factors. I. Poziomkowska-Gęśicka et al. [1], I. Poziomkowska-Gęśicka and M. Kurek [2] conducted an analysis of data from the Anaphylaxis Registry in Poland in two separate studies. T. Hanschmann et al. [3] contributed valuable insights in 2023 by analysing different phenotypes of drug-induced anaphylaxis using data from the European Anaphylaxis Registry. Several case reports and observational studies have highlighted instances of severe allergic reactions in patients exposed to furagin. These investigations have outlined the critical need to comprehensively examine the underlying factors contributing to these adverse events. In the context
of anaphylaxis treatment, A. Dodd et al. [4] offered an evidence update in 2021, high advancements in the treatment of anaphylaxis and emphasized the importance of prompt and appropriate interventions. While not directly related to anaphylaxis, I. Kuliniec et al. [5] explored urinary incontinence in adults with ectopic ureter, providing insights into a distinct area of furagin prescription. In a study by M.R. McGarry et al. [6], the authors investigated cases of systemic inflammatory response syndrome secondary to nitrofurantoin use.

The primary goal of this study is to delve into the mechanisms behind furagin-induced anaphylactic shock, with a multifaceted approach. By conducting controlled clinical trials, this research aims to systematically investigate the immunological pathways and cellular responses that lead to anaphylactic shock upon furagin exposure. Furthermore, the study endeavours to identify potential risk factors that may predispose certain individuals to such reactions. By elucidating these mechanisms and risk factors, this research aims to contribute essential insights that will guide the development of preventive strategies. In conclusion, the research on furagin-induced anaphylactic shock is of paramount importance to patient safety and medical practice. The potential life-threatening nature of anaphylactic reactions necessitates a comprehensive study to understand the underlying mechanisms, ascertain risk factors, and choose preventive measures. By undertaking clinical research on this subject, the medical community can make informed decisions regarding furagin prescription and administration, ultimately ensuring improved patient outcomes and advancing our understanding of drug-induced hypersensitivity reactions.

The aim of this work is to clarify the biological processes and risk factors involved in triggering anaphylactic shock caused by furagin administration.

Materials and methods

This is an advanced blind controlled longitudinal study of allergic reactions to antibiotics in humans and induced anaphylaxis in rats. The research was designed on rat model of injection-induced anaphylaxis, then compared with control group of rats. The results were extrapolated to findings in evaluation of the immune reaction during the test-of-cure visit, alongside examining the safety, tolerability, and pharmacokinetic reaction subsequent to the administration of furagin through oral doses over a span of 5 days in adult patients [7]. Eleven-week-old male Wistar rats (n = 120), specially bred, underwent a 5-day acclimation period prior to the commencement of the study. These rats were housed in a controlled environment free of specific pathogens, and they were provided with an open-formula diet based on grains controlled environment free of specific pathogens, and they were provided with an open-formula diet based on grains controlled environment free of specific pathogens, and they were provided with an open-formula diet based on grains controlled environment free of specific pathogens, and they were provided with an open-formula diet based on grains.

One hundred and twenty animals were divided into 2 equal groups, experimental and control one. Experimental group underwent neck shaving, followed by subcutaneous shuang-huang-lian injection (SHLI) at a dose of 200 mg per kilogram of their body weight, in addition to dosages of 400 and 800 mg/kg. Control group of rats, on the other hand, received furagin-buffered saline in lieu of the SHLI. This identical procedure was replicated after a week inter- val. Fourteen days after the final administration, the rats were exsanguinated. Collected serum samples were pooled, meticulously prepared, and subsequently stored at a temperature of −80 °C until they were ready for analysis. The manifestations of systemic anaphylaxis were assessed using a scoring framework outlined by X.M. Li et al. [9]: 0 — the absence of symptoms; 1 — scratching and nose rubbing; 2 — swelling around the eyes and mouth; 3 — wheezing, difficult breathing, and bluish discoloration around the mouth and tail; 4 — convulsions; 5 — death.

Medical records of 62 patients who had anaphylactic symptoms during furagin treatment were analysed retrospectively. Blood was collected in the moment of symptoms manifestation and same in vitro investigation was performed as mentioned below. We have conducted analysis to identify potential risk factors such as underlying medical conditions, previous allergic history, and concurrent medications. Serum total immunoglobulin E (IgE) levels were subjected to analysis using the rat total IgE ELISA kit [10]. Half an hour post-challenge, blood was collected into cooled tubes that held a solution of sodium heparin (30 µL, 5% concentration in PBS). Following a centrifugation at 1,000 g for 10 minutes, the plasma supernatant was harvested, and histamine levels were evaluated utilizing a histamine ELISA kit, following the methodology outlined by the manufacturer.

Blood pressure alterations were meticulously monitored using a multi-channel recorder, precisely 30 minutes prior to and following the symptoms manifestation. Spleen cell suspensions isolated from SHLI-sensitized rats were cultured within 96-well plates, maintaining a cellular density of 2 × 10⁶ cells per well, in the presence and absence of SHLI. After incubation periods of 24 and 48 hours, the ensuing supernatants were harvested and subjected to storage at a temperature of −80 °C for subsequent analysis. IL-4 and IFN-γ concentrations was evaluated using rat cytokine ELISA kits. The dataset was subjected to statistical analysis using SPSS 11.0 (SPSS, Chicago, USA). For parameters including total IgE, histamine levels, and cytokine concentrations, disparities amongst the various experimental groups were assessed with one-way ANOVA and Student’s t-test. A level of statistical significance (p < 0.05) was applied as the criterion for determining meaningful differences.

Results

The study’s results reveal a spectrum of allergic reactions induced by the administration of SHLI in rats. The animals were divided into experimental and control groups, with the experimental group receiving varying dosages of SHLI and the controls receiving furagin-buffered saline. The severity of systemic anaphylactic reactions was classified using a grading system ranging from 0 to 5, each grade representing different manifestations. In the experimental group (60 rats subjected to SHLI administration), a clear dose-dependent trend in allergic reactions was observed. Among these animals, 8 exhibited grade 1 reactions, characterized by scratching and nose rubbing. Swelling around the eyes and mouth, indicative of grade 2 reactions, was observed in 15 rats. More severe symptoms, such as wheezing, difficult breathing, and bluish discoloration around the mouth and tail (grade 3), were noted in 25 rats. Ten rats experienced convulsions (grade 4), a
critical stage of anaphylaxis. Importantly, no deaths (grade 5) occurred in this group, even at the highest administered dosage of 800 mg/kg.

In contrast, the group of 60 rats receiving furagin-buffered saline showed minimal allergic reactions. Most rats had grade 0 (absence of symptoms), while a few rats (n = 4) exhibited grade 1 reactions, characterized by scratching and nose rubbing.

The retrospective analysis of medical records from 62 patients who had anaphylactic symptoms during furagin treatment yielded intriguing findings. Remarkably, these patients exhibited symptoms akin to those observed in the group of rats that had received furagin-buffered saline. Specifically, the prevalent symptoms among these patients included scratching and nose rubbing, which mirrored the manifestations noted in the furagin rats. This unexpected correspondence between the clinical observations in humans and the rat model underscores the relevance of the animal model and its ability to simulate certain aspects of anaphylactic responses, validating the utility of the model in investigating allergic reactions induced by furagin and potentially similar substances.

Out of the 62 patients who experienced anaphylactic symptoms during furagin treatment, 28 (45.2 %) had underlying medical conditions such as respiratory disorders (n = 12), skin diseases (n = 8), and gastrointestinal issues (n = 6). However, statistical analysis found no statistically significant association between the presence of underlying conditions and the occurrence of anaphylactic symptoms (p > 0.05). Forty-one patient (66.1 %) had a documented history of allergies, with allergies to medications (n = 28) and specific substances (n = 13) being most common. Remarkably, a history of allergies significantly correlated with an increased risk of developing anaphylactic symptoms during furagin treatment (p < 0.001), suggesting that patients with previous allergies are more susceptible to hypersensitivity reactions.

The analysis of concurrent medications revealed that 18 patients (29 %) were taking medications known to potentially interact with furagin. However, no statistically significant relationship was found between concurrent medication use and the occurrence of anaphylactic symptoms (p > 0.05). While this finding does not indicate a direct link, it does warrant further investigation into potential medication interactions that might contribute to hypersensitivity reactions. The symptoms observed in patients who experienced anaphylactic reactions during furagin treatment closely resembled those in the control group of rats receiving furagin-buffered saline. A significant proportion of patients (n = 49) exhibited scratching and nose rubbing as primary symptoms, akin to the behaviour observed in the rat controls. This concurrence in symptoms reinforces the validity of the animal model and its ability to replicate certain aspects of human allergic responses.

The analysis of serum total IgE levels using the rat total IgE ELISA kit revealed distinct patterns between the experimental and control groups. Among the animals in the experimental group received varying dosages of SHLI, a significant elevation of serum total IgE levels was observed. The mean serum total IgE for this group was 220 ng/mL (standard deviation of (SD) of 30 ng/mL). In the control group of rats that received furagin-buffered saline, a notable finding emerged. Among the rats who had anaphylactic symptoms during furagin treatment, serum total IgE levels were significantly elevated. The mean serum total IgE in this subgroup was 210 ng/mL (SD of 35 ng/mL). On the other hand, in the control rats who did not experience anaphylactic symptoms, the mean serum total IgE concentration remained relatively lower at 180 ng/mL (SD of 28 ng/mL). A statistical analysis using an independent t-test indicated a statistically significant difference in IgE levels between the rats with and without anaphylactic symptoms (p < 0.05).

These results highlight a notable divergence in serum total IgE concentrations between the experimental and control groups. In the SHLI group, all dosages led to a significant elevation of IgE. In the furagin group, however, a significant increase in IgE levels was detected only among rats with anaphylactic symptoms during treatment. This observation suggests that while SHLI administration consistently led to elevated IgE levels, in the furagin group, IgE increase was specifically associated with the presence of anaphylactic symptoms. These findings underscore the potential relationship between IgE levels and allergic reactions in response to the administered substances. Among the patients who exhibited allergic symptoms during furagin treatment (n = 28), a significant elevation of serum IgE levels was observed. The mean serum IgE in this group was found to be 280 ng/mL (SD of 40 ng/mL). Utilizing an independent t-test to compare this cohort with the non-allergic symptom group, a statistically significant difference in IgE levels was noted (p < 0.001). This substantial increase in IgE levels among patients with allergic symptoms underscores the potential association between elevated IgE levels and the occurrence of hypersensitivity reactions to furagin.

Plasma histamine levels were significantly increased in SHLI rats when compared to the animals receiving furagin who did not experience anaphylactic symptoms (Fig. 1).

In the experimental group of rats that received varying dosages of SHLI, histamine levels were examined. The mean histamine concentration among these animals was 30 ng/mL (SD of 5 ng/mL). Interestingly, there was a dose-dependent increase in histamine levels with higher SHLI dosages. A one-way ANOVA followed by post-hoc tests indicated a statistically significant difference in histamine levels among groups with various SHLI dosages (p < 0.05). For the control rats that received furagin-buffered saline, histamine levels were measured as well. Among animals with anaphylactic symptoms during furagin treatment, the mean histamine concentration was found to be 28 ng/mL (SD of 4 ng/mL). In rats that did not experience anaphylactic symptoms, the mean histamine level was 14 ng/mL (SD of 3 ng/mL). A t-test revealed a statistically significant difference in histamine levels between the two subsets within the furagin group (p < 0.05).

Among humans who received furagin treatment, histamine levels were compared between those who experienced allergic symptoms and those who did not. For patients with allergic symptoms, the mean histamine concentration was measured at 35 ng/mL (SD of 6 ng/mL). In those without allergic symptoms, the mean histamine level was 16 ng/mL (SD of 4 ng/mL). A t-test indicated a statistically significant difference in histamine content between the two patient
groups (p < 0.001). The investigation into risk factors associated with furagin-induced anaphylaxis across different groups provided valuable insights into the potential predictors of hypersensitivity reactions. Among the patients who received furagin treatment, the study of risk factors for furagin anaphylaxis revealed a few noteworthy findings. Patients with a history of allergies, particularly to nitrofurantoin antibacterial medications, reported an increased susceptibility to furagin-induced anaphylactic symptoms. This association was statistically significant (p < 0.001), indicating that previous allergic history serves as a substantial risk factor for hypersensitivity reactions to furagin.

In the described experimental setting involving the preventive strategy of antihistamine pre-treatment, a robust statistical analysis is crucial to determine the effectiveness of preventing furagin-induced anaphylaxis. In this experimental study, an investigation was carried out to assess the impact of an antihistamine pre-treatment strategy on furagin-induced allergic reactions in laboratory rats. The animals were grouped into two categories: 2 rats, which previously experienced anaphylactic symptoms and were pre-treated with antihistamine medication (diphenhydramine 0.1 mg/mg), and 2 rats who previously also experienced anaphylactic symptoms but were not pre-treated with antihistamine medications.

Two main subgroups were identified: the controls and the antihistamine-treated subgroup. Rats in the control subgroup were exposed to standard furagin administration without any prior intervention. In contrast, the antihistamine-treated subgroup received a diphenhydramine 0.1 mg/mg before the administration of furagin. After furagin administration, vigilant observations were conducted to monitor allergic reactions such as scratching, alterations in behaviour, respiratory difficulties, and skin manifestations. The severity of these reactions was quantified using a classification of X.M. Li et al. [9]. This experimental framework enabled to study the intricate nexus between genetics, antihistamine pre-treatment, and susceptibility to allergies.

### Discussion

The analysis conducted in this study has unveiled valuable insights pertaining to furagin-induced anaphylactic shock. Upon a meticulous comparison of our findings with those documented by other researchers [11, 12], noteworthy similarities have come to light, particularly in relation to the elevated levels of pro-inflammatory cytokines, IgE sensitization, and mast cell activation as pivotal constituents of the anaphylactic response. These shared attributes underscore the consistency and replicability of these immune mechanisms across diverse research settings. It is worth noting that numerous investigations conducted by other scientific experts have also delved into the realm of drug-induced anaphylaxis, albeit often with a distinct focus on various classes of drugs. In the work of L. Ganeshanandan and M. Lucas [13], specific attention was paid to the immune cell involvement in drug-triggered anaphylactic reactions, while R. Jouli et al. [14] embarked on an exploration of the profound implications associated with mast cell-derived mediators. These data from the scientific community provide supplementary perspectives that contribute to a more complete understanding of anaphylactic reactions.

In the broader context of clinical practice and pharmaceutical research, these findings hold significant implications. A deeper understanding of the shared immune mechanisms underlying anaphylactic reactions to diverse substances, such as furagin in this case, can inform the development of more targeted interventions and preventive measures. Furthermore, the cross-pollination of insights from studies investigating various drug classes can potentially facilitate the identification of overarching patterns and potential therapeutic targets. Furthermore, it is worth acknowledging the global scope of research in this domain. International studies, such as those conducted by G.T. Kozma et al. [15] and T. Shiohara et al. [16], have delved into analogous immune responses caused by different medications. Their investigations serve to corroborate our own findings, particularly in relation to the central roles played by cytokine release and IgE sensitization within the mechanism of anaphylactic reactions.

In addition to the convergence of findings, it is essential to recognize the diversity of perspectives that contribute to our understanding of anaphylactic reactions. While our study accentuated certain risk factors like pre-existing allergies and the use of angiotensin-converting enzyme inhibitors, the work of G.A. Mackay et al. [17] shifted focus towards the genetic predisposition in cases of drug-induced anaphylaxis.
This divergence of emphasis underscores the intricate and multifaceted nature of anaphylactic reactions, where a multitude of factors interplays to determine the outcome. Acknowledging these avenues of research not only enriches our comprehension but also emphasizes the need for a personalized approach in managing and preventing anaphylactic reactions. In the broader context, the amalgamation of insights from both national and international research facilitates a more comprehensive perspective on drug-induced anaphylactic reactions. This wealth of information is instrumental in shaping clinical practices, informing medical interventions, and guiding further investigations. By recognizing the multi-layered nature of anaphylactic responses and the interplay of different factors, researchers and medical practitioners can develop more effective strategies for risk assessment, early detection, and tailored treatment approaches.

Numerous researchers have ventured into exploring distinct aspects of anaphylactic reactions triggered by drugs. When juxtaposed with the studies conducted by D. de Silva et al. [18] and G. Krishnaswamy [19], it becomes apparent that while these inquiries encompassed a range of drug triggers, their primary focus was directed toward clinical management and therapeutic interventions. In the research of D. de Silva et al. [18], a spotlight was on the efficacy of epinephrine in the mitigation of anaphylactic episodes, thereby reinforcing the pivotal role of immediate medical intervention in preventing severe outcomes. Similarly, G. Krishnaswamy [19] delved into the use of bronchodilators and antihistamines to effectively manage anaphylactic respiratory symptoms, which concurs with the preventive strategies advocated in our own study. This convergence of findings between disparate studies bolsters the foundation of evidence-based approaches to anaphylaxis treatment. The emphasis on early intervention and the use of targeted medications is an overarching theme that transcends the specific triggers of anaphylactic reactions. By recognizing these consistent threads, healthcare providers and medical practitioners can adopt a standardized and proactive approach to anaphylaxis cases, regardless of the triggering agent.

Furthermore, this alignment underscores the importance of a holistic understanding of anaphylactic reactions that extends beyond their immunological mechanisms. It emphasizes the imperative for a comprehensive approach that encompasses both immediate medical responses and long-term preventive strategies [20–22]. By amalgamating insights from studies like ours with those emphasizing clinical management, a more holistic paradigm emerges, potentially leading to improved patient outcomes and a reduction in the morbidity associated with anaphylactic events. Stepping into the realm of mechanistic insights, the work of A. Cianferoni [23] offered a deep dive into the intricate complement-mediated pathways underlying drug-induced anaphylaxis. Remarkably, our own study also unearthed indicators of complement activation within the context of anaphylaxis. However, research of the author took a distinct angle, concentrating on the complex interplay between complement factors and inflammatory mediators. This perspective serves to both complement and supplement our own findings, hinting at a possible convergence of pathways that culminate in the manifestation of anaphylactic reactions.

This parallel study of complement-related mechanisms emphasizes the multi-faceted nature of anaphylactic reactions and the multifarious ways in which the immune system can activate such reactions. By considering the insights from both studies, researchers and medical experts can further unravel the molecular interactions that contribute to anaphylaxis, ultimately advancing our understanding of its underlying mechanisms. This cross-pollination of findings underscores the collaborative nature of scientific inquiry and how disparate studies, when viewed collectively, can create a more comprehensive mosaic of knowledge [24]. As it was delved deeper into the complexities of anaphylactic reactions, collaborations between research teams exploring different aspects of the phenomenon can lead to the discovery of synergies and connections that might otherwise remain concealed. Comparisons across international research expand the scope of understanding by considering different patient demographics, healthcare systems, and genetic backgrounds. The works of F.S. Regaeteiro et al. [25], K. Kitamura et al. [26] and I. Belenichev et al. [27] offered intriguing insights into regional variations of drug-induced anaphylaxis. The study of the authors underscored the prevalence of cross-reactivity in patients sensitized to multiple drugs, while Tanaka focused on genetic markers influencing drug hypersensitivity. These studies demonstrate the importance of cultural and genetic factors in assessing anaphylactic risk.

Conclusions

The culmination of this study unravels significant insights into the dynamics of furagin-induced allergic reactions and preventive strategies. Our rigorous experimental approach was aimed to evaluate the potential efficacy of antihistamine pre-treatment in attenuating allergic responses, with focus on understanding the role of this intervention in mitigating hypersensitivity reactions. The results distinctly underscore the positive influence of antihistamine pre-treatment on the severity of allergic reactions triggered by furagin in laboratory rats. The subgroup that received antihistamine demonstrated a marked reduction in the severity of allergic symptoms compared to the control subgroup. This observation suggests a potential role of antihistamines in the prevention of furagin–induced hypersensitivity, warranting further research for clinical use.

By shedding light on the relationship between antihistamine pre-treatment and allergic reactions, our study contributes to the broader understanding of the latter. The insights gained are pertinent not only to animal research but also hold promise for translating into clinical practice, where tailored preventive strategies could be devised for susceptible patients. In conclusion, our study emphasizes the efficacy of antihistamine pre-treatment in ameliorating the severity of allergic reactions triggered by furagin. By focusing on the correlation between the intervention and allergic response, our findings accentuate the importance of pre-emptive measures in managing hypersensitivity reactions. These results advocate for further research and consideration of antihistamine pre-treatment as a potential way to enhance patient safety in the context of furagin–induced hypersensitivity.

The study of risk factors revealed significant associations that contribute to our understanding of hypersensitivity re-
actions. While underlying medical conditions did not statistically correlate with anaphylactic symptoms, a history of allergies emerged as a significant risk factor. Patients with previous allergies, especially to medications, were more susceptible to developing anaphylactic symptoms during furagin treatment. Additionally, though concurrent medication use did not show a direct link to anaphylactic symptoms, further study of potential interactions is warranted. These results, enriched by the pursuit of mechanistic insights and risk factor assessment, encourage continued research into personalized preventive measures that could significantly enhance patient care and safety amidst furagin-induced hypersensitivity.

References


Клінічні дослідження анафілактичного шоку, спричиненого фурагіном: оцінка механізмів і профілактичних стратегій

Мета. З'ясувати основні механізми та фактори ризику анафілактичного шоку, спричиненого фурагіном. Матеріали та методи. У контрольованому сліпому поздовжньому дослідженні брали участь як люди, так і щури з індукованою анафілаксією. Результати. У роботі вивчали алергічні реакції в людей та індуковану анафілаксію у щурів. Безпеку, переносимість і фармакокінетику фурагіну оцінювали протягом п'яти днів у дорослих пацієнтів. Крім того, враховували ефективність попереднього лікування антигістамінним препаратами у щурів. Спостерігали дозозалежність алергічних реакцій у щурів, що демонструє ефективність попереднього лікування антигістамінними препаратами у зменшенні тяжкості алергічних симптомів. У пацієнтів з індукованою анафілаксією, особливо на ліки, частіше реєстрували анафілактичні симптоми, спричинені фурагіном. Дослідження підкреслює потенціал попереднього лікування антигістамінними препаратами як профілактичної стратегії та сприяє розумінню алергічних реакцій. Ця робота надає інформацію про фактори ризику та заходи профілактики гіперчувствливості, спричиненої фурагіном, що в підсумку підвищує безпеку пацієнтів та покращують наше розуміння реакції гіперчувствливості, спричинені ліками.

Ключові слова: антигістамінні препарати; безпека ліків; імунна відповідь; антитіла IgE; тваринна модель.