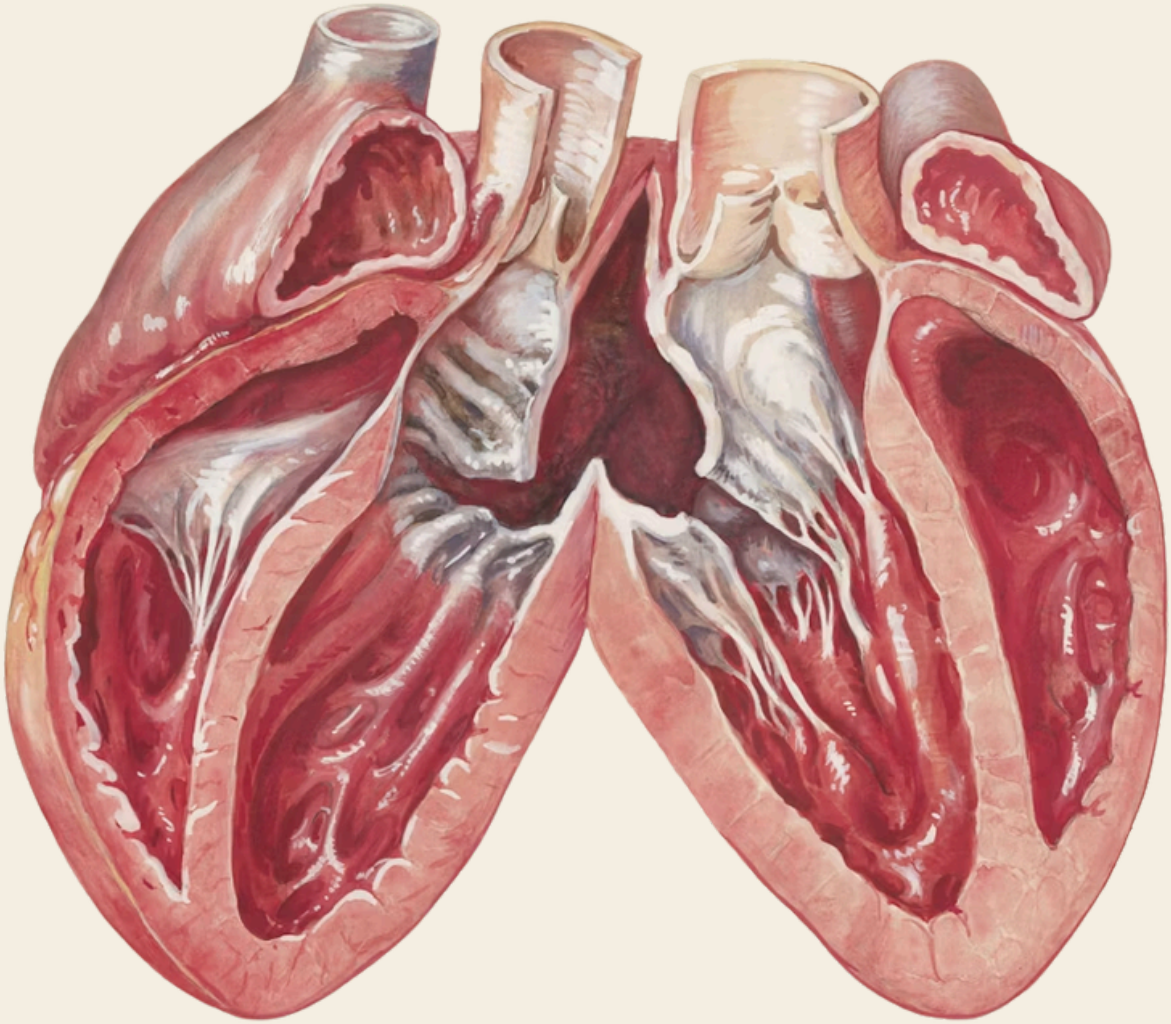
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The Journal of the Physician in Training is a biannual scientific publication edited by medical students from various medical schools across Mexico. It is dedicated to share knowledge in the health sciences through the publication of original research, reviews, case reports, reflective articles, academic interviews, and other contributions of interest to the medical and scientific community.

The journal aims to strengthen the academic, scientific, and professional training of students, medical residents, faculty, and researchers, promoting research, critical thinking, and evidence-based medicine as cornerstones of the development of the health sciences.

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Message from the Editor-in-Chief

It is an honor to present this new issue of the ***Journal of the Physician in Training***, a publication born from a commitment to fostering the academic, professional, and personal growth of health sciences students.

Creating is uncomfortable. It is much easier to consume knowledge than to produce it; much easier to follow a pre-established path than to forge a new one. Creating involves confronting uncertainty, making mistakes, starting over, and dedicating countless hours to building something that, at first, exists only as an idea.

However, it is precisely this process that shapes a professional. Research not only generates evidence; it develops discipline, critical thinking, creativity, and problem-solving skills. Every completed project yields a result, but it also leaves a different person than the one who began it.

Medicine needs professionals capable of creating. Today we have extraordinary tools, including artificial intelligence, that facilitate our work like never before. But none of them can replace the curiosity, judgment, and will that give rise to a new idea.

The works that make up this issue are examples of this. Behind every manuscript was someone who decided to invest time, effort, and perseverance to contribute something unique to scientific knowledge. And perhaps that is the greatest achievement of the process: discovering that we are capable of far more than we ever imagined. Often, the limits lie not in our abilities, but in what we believe is impossible to attempt.

Every publication, every discovery, and every great work began in exactly the same way: as an idea that seemed impossible to someone who decided not to give up on it.

Everything is possible for a willing heart.

Miguel A. S. Lecuona
Editor-in-Chief

In this issue

This issue of the Journal of the Physician in Training brings together contributions that reflect the diversity of the health sciences and a commitment to scientific advancement, innovation, and medical education. Through interviews, literature reviews, and reflective articles, readers will find a comprehensive overview of current topics in clinical practice, medical education, public health, and biomedical research.

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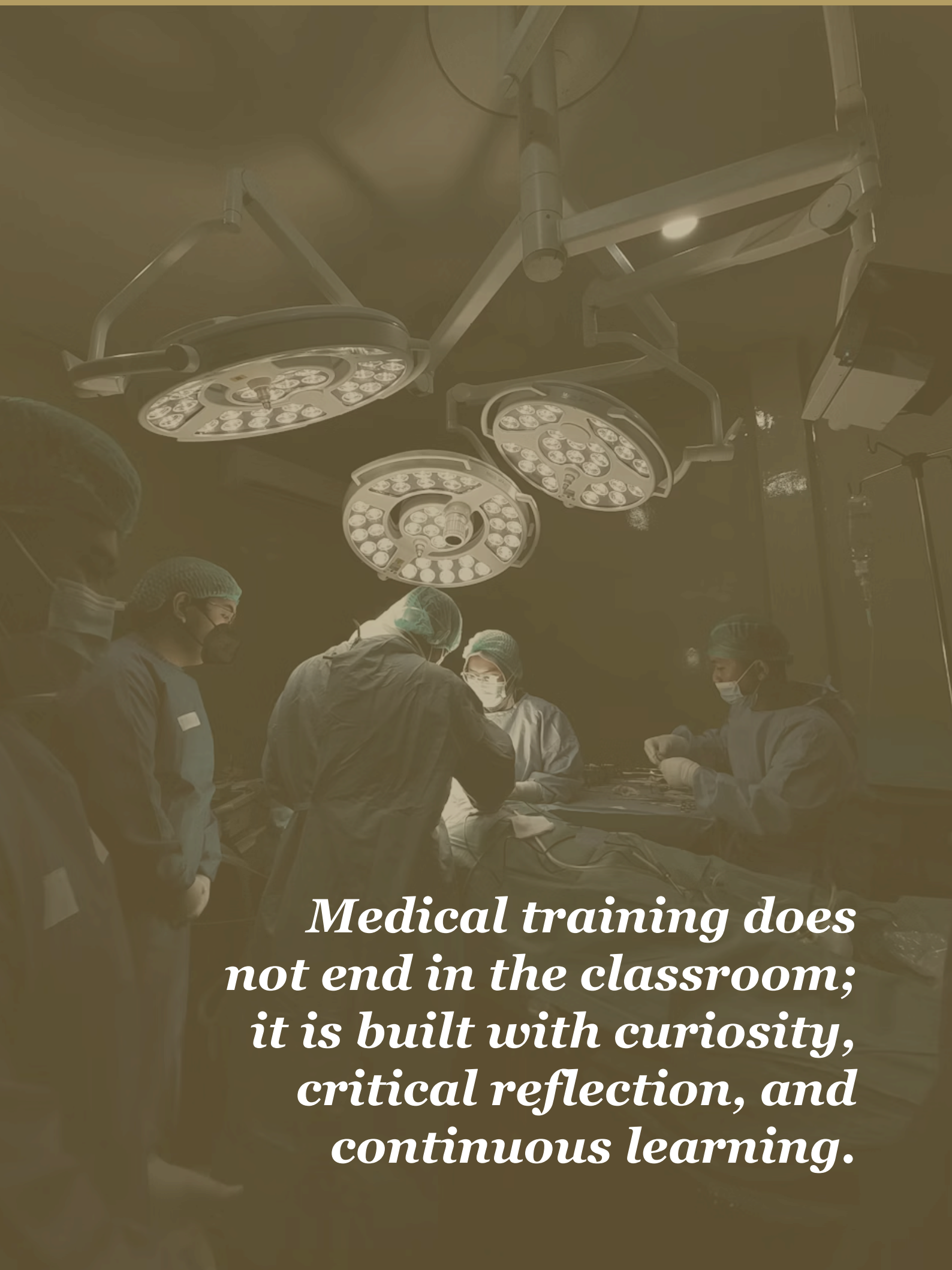
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JOURNAL OF THE PHYSICIAN IN TRAINING



Medical training does not end in the classroom; it is built with curiosity, critical reflection, and continuous learning.

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Celebrating Dr. Francisco Javier Valadez Castillo: Reflections of a Pioneer in Medical Education

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ABSTRACT

Wednesday, March 6, 2024.
Interview conducted by Yahir Alejandro Chico Alcaraz and Christian Joshué Monge Ortega, medical students at the Autonomous University of San Luis Potosí.

On this occasion, we celebrate the life and career of Dr. Francisco Javier Valadez Castillo, a distinguished endocrinologist and professor at the Faculty of Medicine of the Autonomous University of San Luis Potosí, whose passion for teaching and commitment to the training of future healthcare professionals left an indelible mark.

Throughout his career, Dr. Valadez not only imparted medical knowledge in Endocrinology and Internal Medicine, but also inspired countless students and healthcare professionals with his wisdom, empathy, and dedication.

In this interview conducted in March, Dr. Valadez shared his valuable reflections on medical education, his experiences, his work, and the lessons he considers essential for new generations. Through his words, we continue to learn and appreciate the legacy of a true pioneer in medicine.

Keywords: interview, medical education, experience.

Could you tell us a little about your career as a doctor and teacher at the Faculty of Medicine?

I entered the Faculty of Medicine in 1988 and began working in the Reproductive Biology Laboratory, as my prior training warranted. I was an internist, I completed endocrinology residency, and I earned a Master of Science degree in research and postgraduate studies at the University of Iowa in the United States. After some time, I took charge of a course then called "Nutrition, Growth, and Development," which was Applied Biochemistry. What we did was apply all the biochemical concepts to clinical practice, with the intention of making the learning of biochemistry less tedious for students. Previously, we were made to memorize the Krebs Cycle and similar concepts, which are not really useful for clinicians. While it's important to see and understand them, the key is knowing how to apply them and extract information from these models to use in clinical practice.

Later, in 1997, the opportunity arose to found the Master's Program in Clinical Science Research. Later, with a group of professors who held master's degrees (from the faculty), we formed an association with the Faculty of Dentistry and founded the Master's Program in Clinical Research. Its main objective was to prepare specialist physicians to conduct high-quality clinical research, since one of the major problems we see in "everyday" medical publications is that many study designs are poorly prepared, poorly evaluated, or simply not suitable for obtaining reliable results.

I worked on this for 27 years until my retirement. Alongside all of this, since I entered the faculty, I actively participated in the Endocrinology and Nutrition courses at the Faculty of Medicine throughout those years.

Another activity I undertook was participating in the Faculty of Medicine's first accreditation process with COMAEM, an institution that endorses and certifies the quality of medical schools, which involved a significant amount of work at the time.

Later, the directors during their respective terms invited me to coordinate the efforts to modify the curriculum. The process of articulating these subjects and analyzing their content—that is, ensuring their consistency with the type of physician we wanted to train—constituted the entire curriculum review process. Until 2000, the same curriculum, which hadn't been revised for decades, was in place, so a process was initiated to modify it, eliminating some subjects and adding others. This led to a radical change in the way medicine was taught at the Faculty of Medicine starting in 2002. Subsequently, we made another curriculum adjustment in 2013 and finally in 2019 to adapt to the current model: we were offering a seven-year program, while virtually all other medical schools offered six-year programs. The justification for such long programs (seven years) had been, for many years, the desire to train high-quality general practitioners. The problem is that if you graduate as a general practitioner today, you have very little chance of job success: there are no openings for general

practitioners in hospitals or public health institutions. What options do you have as a general practitioner without these opportunities? You'll likely face unfavorable work situations. It's a significant effort for a student to spend seven years studying only to end up in such circumstances.

So, once again, the curriculum was adapted to modern times. For example, previously, a Pediatric Surgery course was offered in the fifth year, which was outdated and unnecessary for the training of a general practitioner. This led to a dilution of knowledge and caused students to forget a great deal of useful information, such as how to treat a hypertensive or diabetic patient, how to recognize a patient with a common infectious disease, how to properly treat a urinary tract infection, or how to effectively correct a case of dehydration, among other information.

So the idea is to make the preparation we give our students increasingly robust. Ninety percent or more of UASLP graduates become specialists, something that was heavily criticized years ago. It was said that we trained specialist doctors, not general practitioners. Therefore, I proposed that passing the EGEL exam be considered as an evaluation criterion to meet the standards required to be a general practitioner in the country, and that graduates have the necessary tools to become specialists.

Regarding my time working with the master's students, we published around 135 articles in nationally and internationally indexed journals, and when the CONACYT program for evaluating quality programs was in place, UASLP consistently maintained its accreditation throughout my tenure.

What can you tell us about the most recent changes made to the curriculum? Do you believe these changes have had a positive effect? What do you consider crucial for UASLP medical students to become high-quality professionals?

Regarding the results of the 2019 curriculum adjustment, we don't yet know because we don't know the final performance of this current cohort. Given that approximately 50,000 applicants apply to the specialization each year, and only 18,000 are accepted, we have maintained a good number of graduates from the faculty who have met these standards and are entering a specialization program, which keeps us calm for now.

However, it doesn't all depend on the schools; it's also crucial that students are consistent in order to master the knowledge, which isn't easy. The major problem we now face with students is that the preparation they've received in previous years is crucial. I believe there are three fundamental elements in student preparation:

- Individual talent: innate abilities of each student, like someone who is very fast in a marathon and is able to beat someone who trains a lot.
- Preparation prior to university: their prior academic training and study skills.
- Willpower: The fact that few students are consistent with their studies and rarely arrive prepared for class, with many simply focused on passing exams, means that they have to make a greater effort before preparing for the CENEVAL exam.

From the university's perspective, library support and faculty support are crucial.

What pedagogical approaches did you use to teach medical students?

Having a clear program with well-defined class objectives, using clinical cases as a starting point to arrive at the basic concepts. All in an active class where students prepare and participate in discussion sessions and talks about the information they gather.

What motivated you to become a teacher and to motivate students to become researchers?

I am convinced that the only path we have in this country to improve is through education. Currently, we need people who are free-thinking, analytical, and proactive. It's valid to criticize as long as you have a proposal, but likewise, if criticism is acceptable, then offering a solution is obligatory. It's important to have people who take action and generate solutions. For this reason, I have always been committed to education in order to improve my environment, influencing it as a professor and facilitator of these curricular changes.

I believe that the educational process never ends; it requires continuous changes. With current advancements, we have made incredible leaps, which implies great efforts to organize current curricula that need more active updating. Professors like myself strive to ensure that the faculty remains a leading center for training professionals, especially since it is a public university. This provides more young people with the opportunity to study, as private schools are prohibitively expensive. This helps improve the social conditions of students who usually come from a lower socioeconomic background.



Figure 1. From left to right: Christian Monge, Dr. Francisco Valadez, Yahir Chico.

What do you consider to be the most important aspects of your career as a doctor and teacher?

The three curricular changes that the university achieved under my coordination, the accreditation of the Faculty of Medicine and the foundation and permanence of the Master of Science in Clinical Research.

Based on the above, what do you think will have the greatest legacy in the future?

I believe that the curriculum changes are worthwhile, since we left a file where we documented all the changes, so future administrations can consult the information and background of the work we did.

In your opinion, what do you consider to have been the biggest challenges you faced during your career as a teacher at the Faculty of Medicine of the UASLP?

Resistance to change exists among both teachers and students. Some teachers consider their own subjects more important and tend to undervalue others, largely due to generational differences and the belief that education should remain the same as before.

The biggest problem is the lack of communication among the teaching staff, which hinders the development of collaborative work.

Do you believe that this resistance to change comes exclusively from the teaching staff or also from the student body?

I believe it can come from all of them; however, the most important problem in the case of curriculum change originates from the teaching staff and the inability to communicate among its members.

Do you have any anecdotes or memorable stories from your time as a teacher that you would like to share?

Perhaps the students' response during the accreditation process was the most striking. We were concerned that the students themselves weren't aware of what we were doing. So, we gradually began meeting with them and managed to motivate them. I was very pleased with their response: everyone got involved, everyone helped (much more than the faculty), and we were able to successfully complete the process.

This was particularly noticeable when we tried to repeat the experience during the faculty's 140th anniversary celebration, revealing a different attitude among the students, who demanded some kind of reward. It's painful to observe that medical students at that time already had a very clear intention of obtaining benefits—not financial, but benefits of another kind. I believe the most serious issue is the growing unwillingness to share their own time.

What do you think is the reason behind this?

I don't know for sure; perhaps society's own evolution is heading in that direction. It's possible that in the past there was a greater willingness to cooperate and a vision that wasn't limited to what the school did for the individual, but also included what each person contributed to their institution.

For this reason, I was pleased to participate in this interview, as I see that you are doing something proactive, contributing something new. You are investing your time in something that benefits the students and the faculty as a whole.

What do you consider to be the most notable changes among medical students from when you started teaching compared to today?

I believe that starting to demand without giving was like going from an upward slope, where there was a greater willingness to cooperate, to a downward slope where the student wants, demands, and doesn't contribute, at least until 2019, when I still maintained a closer relationship with the students.

Today, technological tools are considered important for medical students, but do you think there are any disadvantages to using them?

Undoubtedly, technological tools have been extremely useful not only for students, but also for teachers and healthcare professionals in general. However, I believe their main drawback is that their effectiveness depends largely on who uses them and how they use them, since not everyone knows how to use them appropriately and responsibly.

What is your opinion on the current educational system for medical training? What would you change?

I think it's good, but not enough. I believe the most efficient models I know are the ones I used in an Endocrinology course I taught entirely, with around 20 to 30 students. There, I could organize my classes as I wanted and keep the pace according to my plan. At least I knew everyone by name, unlike in classrooms with over a hundred students, where I don't even know their faces.

The lecture format is important; after all, that's how medical conferences work. However, I believe that in basic training, it's vital to nurture the student-teacher relationship. That's one change I would make.

Finally, based on your vast experience as a physician and teacher, could you share any valuable advice or final comments that will endure among medical students currently in training and for the future?

First, I believe it's essential to look inward and reflect on whether you truly love this profession. That's the first question I suggest you ask yourselves. And if you truly become convinced that this is the profession to which you want to dedicate your entire life, embrace it with all the will and talent you can muster, without setting limits.

Never be complacent after hearing and repeating everything. It's necessary to research, read, seek, and get involved. Medicine demands that level of commitment.

If you're not passionate about your profession, it becomes a heavy burden, and only you and your conscience will tell you if you're truly making the most of your time in all aspects of your life.

Finally, another recommendation I would give you is to constantly ask yourselves what you do for your school, what you contribute, and what you can do, as a student, to help make your institution better, remembering that if you love the profession and the degree you're studying, the least you can aspire to is to contribute, and I believe that's precisely what you're doing.

We wish to express our sincerest gratitude to Dr. Francisco Javier Valadez Castillo for granting us the invaluable opportunity to conduct this interview. From our first contact, his trust in our project deeply honored us.

Throughout our conversations, which extended beyond the formal interview, Dr. Valadez generously shared the most significant experiences from his distinguished career as a physician and professor at the Faculty of Medicine of the Autonomous University of San Luis Potosí.

His knowledge and passion for teaching and medicine enriched our understanding and offered us an invaluable perspective. His dedication to the profession and his commitment to training new generations of physicians leave a lasting mark on all those who had the privilege of knowing him and learning from him.

His legacy will continue to inspire and guide us on our professional paths.



In memory of Dr. Francisco Javier Valadez Castillo

Skin Cleansers and Epidermal Barrier: A Narrative Review

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ABSTRACT

Introduction. Skin hygiene is essential, but the type of cleanser, its pH and the pattern of use determine the impact on the barrier function and the risk of irritant dermatitis. This review summarizes damage mechanisms and comparisons between alkaline soaps and syndet/moisturizing cleansers.
Methods. Narrative review under SANRA. Source: PubMed/MEDLINE (Humans; last 10 years). Reproducible strategy with MeSH terms/keywords related to cleansers, skin barrier and TEWL. Last search: Nov 1, 2025. Inclusion: human studies evaluating pH, TEWL, capacitance/hydration, NMF or clinical signs. Exclusion: animals, editorials without data, duplicates. n=53 articles were identified.
Results. Alkaline soaps raise pH, draw lipids from the stratum corneum, and increase TEWL; Frequent washing, wet work and occlusion with gloves increase the damage. In contrast, syndets (pH 4.5–5.5; nonionic/amphoteric surfactants) and wetting cleansers show less impact on pH/TEWL and better tolerance. In intensive hygiene scenarios, hydroalcoholic solutions with emollients may be less lipid-reducing than repeated washing with soap.
Conclusions. For daily and repeated use, it is recommended to prefer syndets with physiological pH or moisturizing cleansers, minimize friction and contact time, alternate with ABHR with emollients when hygiene is intensive, moisturize immediately after washing and limit occlusion. Standardized comparisons (pH/TEWL/capacitance) and longer studies are required in atopic dermatitis, older adults, and high-risk occupations.

Keywords: skin barrier, transepidermal water loss, irritant contact dermatitis, soaps.

INTRODUCTION

The skin constitutes the body's main protective barrier against the external environment, with the stratum corneum (SC) being the fundamental layer responsible for this function. This structure maintains a delicate homeostasis that prevents excessive water loss and blocks the penetration of harmful substances [1].

Skin hygiene is an essential practice for health and infection prevention, the importance of which has been accentuated in high-demand contexts such as the COVID-19 pandemic [2]. However, the frequent use of cleansing agents presents a dilemma: the need for cleansing directly conflicts with preserving the integrity of the skin barrier [3].

Traditional alkaline soaps contain anionic surfactants such as sodium lauryl sulfate (SLS), known to alter the lipid and protein architecture of the stratum corneum and, therefore, induce skin irritation [4,5]. This effect results from simultaneous mechanisms, including the elevation of pH towards neutral or alkaline values, which increases epidermal permeability and compromises the activity of acid mantle-dependent enzymes, essential for the maturation and repair of the skin barrier [6,7].

Furthermore, surfactants solubilize intercellular lipids and denature structural proteins such as filaggrin, which clinically translates into increased transepidermal water loss (TEWL) and decreased natural moisturizing factor (NMF) [1].

Repeated exposure to these irritants leads to a state of chronic microinflammation, characterized by the release of proinflammatory cytokines and sensitization of neural pathways that mediate pruritus [8].

This disruption of the skin barrier increases susceptibility to irritant contact dermatitis (ICD), especially in vulnerable populations or those with high occupational exposure [9]. In contrast, syndets (synthetic detergents) and moisturizing cleansers, formulated with milder surfactants and a physiological pH, have demonstrated a better ability to preserve the enzymatic activity and cohesion of the subcutaneous layer [6].

The aim of this narrative review is to analyze the pathophysiological mechanisms by which skin cleansing products compromise the barrier function, compare the irritation profile of alkaline soaps versus syndet cleansers, and offer a comprehensive perspective on the clinical implications of these alterations in the prevention and management of irritant dermatitis.

METHODS

For the development of this work, a narrative review was carried out following the guidelines of the SANRA scale (Scale for the Quality Assessment of Narrative Review Articles). The literature search was performed in the PubMed, Cochrane, Ovid, and Scopus databases, applying filters to limit the results to studies conducted in humans and published within the last 10 years.

The closing date for the final search was November 1, 2025.

The search strategy was structured by combining MeSH terms and specific keywords: ("soaps"[MeSH Terms] OR "cleansers" OR "detergents" OR "syndet" OR "skin cleansing agents" OR "skin cleanser" OR "soap") AND ("skin barrier"[MeSH Terms] OR "stratum corneum" OR "skin barrier function" OR "transepidermal water loss" OR "TEWL" OR "irritant contact dermatitis") AND (irritation OR "irritant effect" OR "skin irritation" OR "cutaneous irritation" OR "dermal irritation").

Regarding the selection criteria, human studies published in the last decade that evaluated objective parameters such as pH, transepidermal water loss (TEWL), skin capacitance and hydration, natural moisturizing factor (NMF), or clinical signs of irritation were included. Conversely, studies using animal models, editorial articles that did not contribute original data, and duplicate records were excluded. After this filtering process, 60 articles were identified for analysis.

The data extraction and quality assessment process was carried out by two independent reviewers, who performed the initial screening by title and abstract, followed by a detailed review of the full text; any discrepancies during this phase were resolved by consensus. Information was extracted from each study regarding the design, population characteristics, type of product evaluated (soap, syndet, moisturizing cleanser, or alcohol-based hand sanitizers [ABHR]), skin barrier metrics, and the main clinical message.

Finally, the analysis was conducted using a qualitative approach, the synthesis of which is presented through a thematic integration organized by mechanisms of action, comparisons between products, risk modifiers, and special clinical scenarios.

RESULTS

- **Function of the Skin Barrier**

The skin is the largest organ of the human body and is the body's first line of defense against physical, chemical, and microbiological aggressions. It is composed of three layers: epidermis, dermis, and hypodermis.

This structure provides an effective barrier between the body and the environment to ensure protection against transepidermal water loss (TEWL) due to evaporation (from the inside out), and a mechanism that prevents the penetration of irritants, allergens, and external microorganisms (from the outside in) [10].

There are three main pathways described for the penetration of substances through the skin: intercellular, transcellular, and transappendix. The intercellular pathway involves the passage of substances between the corneocytes of the stratum corneum; the transcellular pathway directly crosses the epidermal cells; the transappendicular pathway utilizes skin appendages, such as sweat glands, sebaceous glands, and hair follicles, with the latter being the most frequent route for water-soluble molecules [11].

The main function of this barrier is found in the stratum corneum of the epidermis, formed by anucleate corneocytes embedded in a lipid matrix composed of ceramides, cholesterol, and fatty acids. An intact barrier maintains water homeostasis, the skin's natural acidic pH (4.5–5.0), and immunological function mediated by cytokines, immune cells (Langerhans cells), and antibodies such as IgA. Its disruption leads to xerosis, irritant or atopic dermatitis, and increased sensitivity to surfactants [12]. The skin barrier function can be compromised by the repeated use of soaps and surfactants, as well as by conditions such as aging, certain topical medications, rosacea, or atopic dermatitis [13,14,15].

The most common causes of surfactant-induced irritant contact dermatitis include sodium lauryl sulfate and benzalkonium chloride [16].

- **Irritation Mechanisms**

Skin irritation from soaps and other cleansers is explained by interrelated phenomena (Figure 1):

1. *Alteration of Skin pH*

Elevating skin pH toward neutral or alkaline values interferes with enzymes dependent on the acid mantle (lipases, ceramidases) and with the proper degradation of filaggrin, causing disorganization of intercellular lipids, increased epidermal permeability, and an increase in TEWL. Considering that the isoelectric point of keratin is around pH 5, it has been shown that surfactants formulated predominantly with anionic compounds cause greater irritation and dryness compared to those with a more neutral pH, due to an alteration of electrostatic interactions [7,17,18].

Koudounas' study demonstrated that a sustained elevation of pH above 6.5 disrupts the lipid matrix of the stratum corneum and reproduces the irritant effect typical of alkaline soaps [6]. Repeated exposure to alkaline cleansers or frequent washing induces a persistent increase in surface pH and a progressive loss of skin homeostasis, compared to syndets with physiological pH, which even reduce pH after repeated use [17,19]. Patients with atopic and extremely dry skin present higher than normal pH values, around 5.5 or higher; it is unclear whether the change in pH is a cause or an effect of the skin condition [12].

Alkalization of the epidermal microenvironment also affects the commensal flora and amplifies the local inflammatory response, predisposing to irritant dermatitis and exacerbating pre-existing dermatoses, such as atopic dermatitis [14].

Taken together, these findings confirm that maintaining the skin's acid mantle is essential to preserving the integrity of the epidermal barrier and preventing barrier dysfunction induced by alkaline pH soaps.

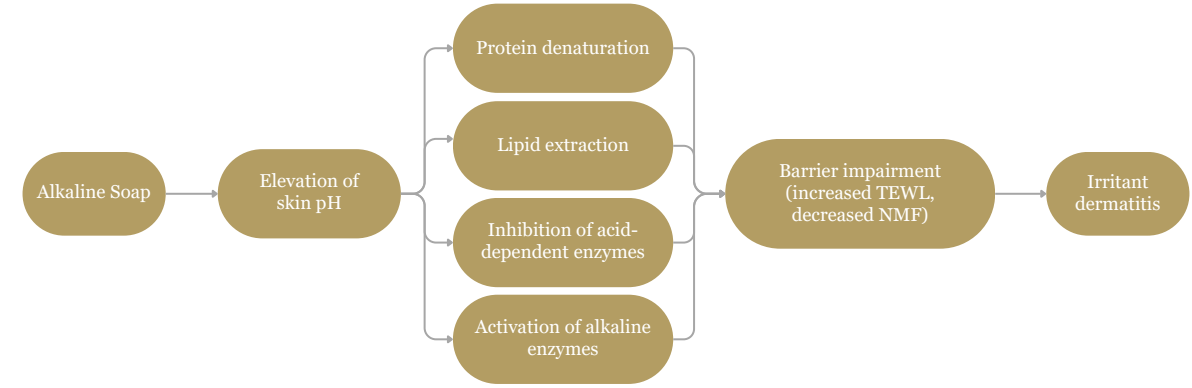


Figure 1. Mechanisms of Irritation by Alkaline Soaps: Pathways of Damage and Convergence to Barrier Impairment. *Original work by the author. TEWL: transepidermal water loss; NMF: natural moisturizing factor*. The diagram illustrates the cascade of pathophysiological events triggered by alkaline soap (pH 8-10). The cleansing agent initiates three main pathways of damage that converge in the impairment of the skin barrier function: 1) Elevation of skin pH, which alters enzymatic homeostasis by inducing the activation of alkaline enzymes and the inhibition of acid-dependent enzymes (essential for lipid synthesis); 2) Denaturation of structural proteins (such as filaggrin); and 3) Extraction of intercellular lipids. The sum of these effects leads to barrier impairment, clinically manifested by increased transepidermal water loss (TEWL) and decreased natural moisturizing factor (NMF), ultimately culminating in irritant dermatitis.

2. *Lipid Removal and Protein Damage*

Anionic surfactants, such as SLS, act as potent lipid-removing and protein-denaturing agents. Their detergent action solubilizes the main lipid components of the stratum corneum (ceramides, free fatty acids, and cholesterol) and alters structural proteins such as filaggrin and involucrin, resulting in a decrease in NMF and an increase in TEWL [16,20,21].

Repeated exposure to SLS has been shown to significantly reduce NMF and impair barrier function in a cumulative irritation model. In atopic skin, the same group showed a more pronounced effect, with a decrease in NMF and a higher TEWL than in healthy skin, demonstrating individual vulnerability to damage. It was confirmed that repeated application of SLS produces an increase in erythema and TEWL even in areas pretreated with protective creams, indicating that topical preventive measures do not always mitigate barrier damage induced by frequently used soaps [4].

The underlying mechanism is related to the extraction of lamellar lipids and the denaturation of corneocyte proteins, which disrupt the cohesion of the stratum corneum and facilitate the penetration of irritants. Anionic surfactants such as SLS and benzalkonium chloride are, therefore, the main culprits behind occupational irritant dermatitis [16].

Furthermore, structural damage is amplified by electrostatic interactions between negatively charged surfactants and positively charged skin proteins, leading to cellular edema, protein denaturation, and loss of barrier integrity [10,16,17].

3. *Keratinocyte Damage, Inflammation, and Microenvironment*

Surface-induced chemical and osmotic stress triggers pro-inflammatory cellular responses in the skin epithelium. Repeated exposure to detergents generates oxidative damage and keratinocyte apoptosis, with the release of cytokines such as IL-1α, IL-8, and TNF-α, which activate an inflammatory cascade responsible for amplifying irritation and barrier dysfunction [22]. The American Contact Dermatitis Society consensus statement noted that these mediators, along with the loss of the skin's natural moisture barrier (NMF) and elevated skin pH, lead to histopathological changes characteristic of irritant dermatitis: spongiosis, dyskeratosis, and persistent chronic microinflammation [3].

Furthermore, the hyperhydrated or alkaline microenvironment modulates the expression of filaggrin and type 2 cytokines (IL-4, IL-13), reproducing an immunological profile similar to that observed in atopic dermatitis. These alterations perpetuate epidermal inflammation and impaired barrier function [14].

4. *Risk factors for irritation*

The extent of skin irritation depends not only on the type of detergent but also on extrinsic (frequency, friction, humidity, occlusion) and intrinsic (atopy, age, previous barrier integrity) conditions (Table 1).

Occlusion and moisture. Prolonged glove use and working in wet conditions enhance the irritant effect of detergents by increasing skin temperature, humidity, and pH. Occlusion increases pH and the penetration of irritants in a dose-response relationship, amplifying barrier damage [23]. It has been observed that the combination of gloves and detergent exposure compromises epidermal integrity even with the use of protective creams, confirming an additive effect between occlusion and irritants [24]. The wet work phenomenon, which refers to repeated exposure to water, surfactants, and friction, causes maceration, lipid depletion, and increased permeability of the stratum corneum. Even in the absence of detergents, prolonged occlusion with gloves reduces barrier function [25].

Friction and repeated trauma. Constant friction or microtrauma promotes loss of corneocyte cohesion and facilitates the penetration of irritants, contributing to the chronicity of dermatitis. This mechanism has been documented in occupations involving mechanical handling or repeated contact with cleaning, cosmetic, or healthcare products [21,26].

Washing frequency and product type. The frequency of exposure is a determining factor; even "mild" soaps or syndets can produce cumulative alterations in TEWL and pH after repeated washings, indicating that irritation depends more on the number of exposures than on the type of product [22]. During the COVID-19 pandemic, excessive washing combined with alcohol-based disinfectants was shown to cause skin dysbiosis, local immune dysfunction, and persistent chronic eczema [2].

Individual predisposition. Genetic and underlying factors, such as atopy or mutations in the filaggrin gene, increase susceptibility to barrier damage and irritation from surfactants [14,21]. Likewise, occupational exposure, such as in health workers, personnel performing cosmetic procedures, and jobs exposed to radiation emitted by the sun, have been described as factors present in the appearance of damage from cleaners [9,21,26–28].

Table 1. Modifiable and non-modifiable factors that increase the risk of soap irritation.

Modifiable Factors	Non-modifiable Factors
• Washing Frequency • Friction • Use of Topical Medications • Contact Time • Water Temperature • Cleanser Formulation • Occlusion (gloves) • "Wet work" • Inadequate Drying • Lack of Post-Wash Emollient Use	• Genetics (atopy, filaggrin gene mutations) • Advanced Age • Previous Occupational Exposure

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- **Comparison of Soaps**

1. *Alkaline Soaps (Saponified, pH 8–10)*

Traditional alkaline soaps, made by saponifying fats with alkalis, have a pH between 8 and 10 and contain anionic surfactants, primarily SLS. These chemical characteristics alter the lipid architecture of the stratum corneum by solubilizing intercellular lipids (ceramides, cholesterol, and free fatty acids) and denaturing structural proteins such as filaggrin and involucrin.

Soaps containing SLS cause a sustained increase in skin pH (from 4.5–5.5 to >7) and an increase in TEWL, which reduces the activity of acid-dependent enzymes such as β-glucocerebrosidase and sphingomyelinase, responsible for lipid regeneration. This disruption promotes epidermal inflammation mediated by IL-1α, IL-8, and TNF-α, clinically manifesting as xerosis, pruritus, erythema, and microfissures, characteristic of irritant contact dermatitis [3].

2. *Syndets (physiological pH, non-ionic and amphoteric surfactants)*

Syndets (synthetic detergents) employ non-ionic or amphoteric surfactants, such as cocamidopropyl betaine or lauryl glucoside, formulated with a physiological pH (4.5–5.5). This range maintains the enzymatic activity of the acid mantle and corneocytic cohesion, reducing TEWL and preserving the skin microbiota [6]. An elevated skin pH has been shown to increase epidermal permeability, demonstrating that syndets, by maintaining physiological acidity, preserve the structural and functional integrity of the stratum corneum.

Clinically, their regular use is associated with better tolerance, less inflammation, and a lower risk of irritant dermatitis in sensitive or frequently washed skin [6].

While liquid syndets with a pH of 5.5 maintain epidermal hydration (TEWL <10 g/m²/h) and prevent irritation, alkaline soaps raised skin pH to 7.1 ± 0.3, reducing lipids and causing transient erythema. These results confirm that syndets are superior in skin compatibility, even in immature or sensitive skin [29].

3. *Moisturizing Cleansers and Combination Formulations*

Moisturizing cleansers incorporate active hydrating agents (urea, glycerin, ceramides) that modulate stratum corneum hydration and compensate for water loss induced by repeated washing. Alcohol-based disinfectants containing urea reduce dryness and redness by restoring the skin's natural moisture barrier (NMF) and improving stratum corneum water retention, without affecting antimicrobial efficacy [30]. Additionally, modified corneosurvep measurement (mCMS) was used to quantify the irritant potential of the cleansers.

Alkaline soaps showed the highest levels of corneocyte damage and protein denaturation, while syndets and moisturizing cleansers maintained cell cohesion and epidermal hydration, exhibiting minimal structural alteration [31].

These findings confirm that formulations with moisturizing agents offer superior protection of the skin barrier, reducing the erythema, scaling, and xerosis observed with prolonged use of conventional soaps.

4. *Antibacterial Soaps and Alternative Agents*

Analysis of antibacterial soaps containing triclosan revealed that their use does not offer greater antimicrobial efficacy than neutral soaps or syndets, but it does cause adverse dermatological and microbiological effects. Triclosan alters the commensal skin microbiota, decreases protective bacterial diversity, and promotes bacterial resistance, in addition to interfering with fatty acid synthesis in keratinocytes, reducing ceramides and increasing TEWL [32].

From a clinical perspective, prolonged use of soaps containing triclosan is associated with chronic irritant

dermatitis and skin dysbiosis, which is why the FDA (Food and Drug Administration) banned its use in general consumer products in 2016. In contrast, alternatives such as chlorhexidine, benzalkonium chloride, and lactic acid have demonstrated adequate antimicrobial efficacy with less irritant potential, depending on the concentration and formulation.

5. *Comparative Evidence and Clinical Applications*

Ex vivo and clinical evidence converges on the fact that alkaline soaps are the most irritating, causing an increase in TEWL, lipid loss, and pH alteration, while syndets with physiological pH and mild surfactants offer greater dermatological compatibility and better maintenance of the skin barrier function [3,6,29].

Moisturizing cleansers with urea or glycerin, on the other hand, provide additional restorative effects by replenishing the skin's natural moisture barrier (NMF) and promoting epidermal regeneration [30,31]. Finally, antibacterial soaps with triclosan pose dermatological and microbiological risks, with no proven clinical benefits compared to syndets [32].

- **Methods for Assessing the Skin Barrier**

Evaluating skin barrier function in response to soaps, detergents, and cleansers requires standardized and reproducible methods that allow for the quantification of structural, biophysical, and clinical alterations induced by these agents. The main parameters used are TEWL, skin pH, stratum corneum hydration by corneometry, erythema by colorimetry, and inflammatory biomarkers obtained by tape stripping (IL-1α, IL-1RA, NMF).

1. *In Vivo Biophysical Assessments*

TEWL is the most widely used quantitative method as an indicator of stratum corneum integrity, reflecting the passive diffusion of water through the epidermis. An increase in TEWL indicates damage or structural disruption of the barrier.

When measuring TEWL, pH, and erythema in in-use forearm models to compare soaps, it was demonstrated that TEWL correlates with the severity of irritant damage [17,19]. The sensitivity of TEWL and pH as measures for assessing the impact of wetwork and repeated friction has been confirmed [4,25]. An automated model (ACiD) was developed that standardizes pressure and washing time, allowing for the quantification of TEWL, hydration (corneometry), erythema (colorimetry), and pH, along with inflammatory markers and NMF (non-facial muscle fibers) using tape stripping [22].

2. *Evaluation of Hydration, pH, and Erythema*

Stratum corneum hydration, measured by corneometry, is a direct marker of surfactant-induced dryness. During the COVID-19 pandemic, the combination of corneometry, TEWL, and pH was established as the gold standard for determining dermal tolerance to cleansers and moisturizers.

Skin pH, measured with pH-metry, is another key indicator. Thus, maintaining a subacid pH (~5.5) preserves enzymatic homeostasis and prevents lipid degradation, while alkaline soaps raise the pH and increase irritation [7,14]. Erythema colorimetry complements these parameters, allowing for the quantification of the inflammatory vascular component associated with barrier damage.

3. *Irritation and Cytotoxicity Tests*

Experimental methods include repeated irritation models such as the Repeated Wash Test (RWT) or the Tandem Repeated Irritation Test (TRIT), which reproduce the cumulative damage from detergent exposure. Their application in the comparative study by Tasar (2021) between alcohols and soaps has confirmed their usefulness in measuring the severity of irritation [33].

In vitro studies have described predictive techniques such as modified corneosurvep measurement (mCMS), protein denaturation (zein or albumin), and reconstructed epidermis models (LSE) with IL-1α/IL-1RA quantification [12]. Cellular cytotoxicity has also been correlated with increases in TEWL and pH, demonstrating a correlation between biochemical damage and functional barrier disruption [18].

4. *Clinical and Occupational Assessments*

In occupational exposure settings, methods combine standardized clinical assessment, exposure interviews, and patch testing. Occupational irritant dermatitis has been documented through detailed occupational history and allergy exclusion via patch testing [21, 28].

Furthermore, glove occlusion has been observed to increase pH and TEWL, contributing to skin barrier impairment even without chemical exposure [23].

In healthcare workers, the combined monitoring of TEWL, pH, hydration, and clinical signs of eczema allows for the detection and quantification of barrier impairment resulting from intensive washing and the use of alcohol-based disinfectants [34,35].

5. *Methodological Integration and Standardization*

The literature agrees that no single parameter fully describes barrier function. The combination of TEWL, corneometry, pH, and erythema constitutes the minimum set of biophysical assessments, while biomarkers obtained by tape stripping (IL-1α, IL-1RA, NMF) and advanced techniques such as CRM (Confocal Raman Microscopy) allow for the detection of subclinical alterations and the evaluation of barrier recovery after the use of cleansers or soaps.

This underscores the need to standardize these methods in surfactant studies, combining instrumental measurements with clinical scales and patch tests to obtain a comprehensive view of skin damage induced by cleansing agents [16,20].

DISCUSSION

The synthesized findings confirm that the damage induced by cleansing products on the skin barrier depends on a multifactorial equation: the nature of the surfactant, the pH of the formulation, the frequency and method of use (contact time, friction), and exposure conditions such as humidity and occlusion. Within this framework, saponified alkaline soaps (predominantly anionic surfactants such as SLS) consistently show a greater increase in TEWL, a sustained elevation of pH, and erythema compared to syndets with physiological pH and non-ionic/amphoteric surfactants, which better preserve corneocyte cohesion and the commensal microbiota [7,12,17,19,20]. These differences are not only biophysical: they correlate with lipid disruption (ceramides/cholesterol/fatty acids), protein denaturation (e.g., filaggrin), and amplification of proinflammatory pathways (IL-1α, TNF-α), the histopathological basis of irritant contact dermatitis [11,16].

The frequency of washing and the "exposure dose," modulated by the context (healthcare, domestic, or occupational), act as risk multipliers. In vivo models and repeated irritation protocols demonstrate that even "mild cleansers" can induce cumulative damage if the number of cycles increases or if friction, high temperature, and aggressive drying coexist [22,24,25]. "Wet work" and occlusion with gloves (due to their impact on humidity, temperature, and pH) enhance the penetration of irritants and impair barrier recovery, even in the absence of added detergent [23,25]. This explains the high incidence of irritant contact dermatitis (ICD) in professions involving frequent handwashing or repeated contact with cleaning solutions [9,21,26,28].

During the COVID-19 pandemic, increased handwashing and the use of alcohol-based hand sanitizers raised the incidence of irritant contact dermatitis [2,32,35]. Although alcohols (n-propanol, isopropanol) have, on average, a lower irritant potential than alkaline soaps, the damage increases when other irritants (detergents) or occlusion by gloves are present [23,33]. Alternating handwashing with soap and alcohol-based hand sanitizers containing emollients, and applying immediate post-wash emollients, reduces the cumulative effect of chemical and mechanical irritation [30,35,36].

Certain populations require specific strategies. In atopic skin or skin with a pre-existing barrier compromise, the "irritation threshold" is lower; Choosing subacid pH syndets and moisturizing/lipid-replenishing formulations reduces relapses and better maintains skin elasticity [7,12,14]. In older adults, the decrease in natural moisture barrier (NMF) and ceramides makes it advisable to avoid alkaline soaps and favor cleansers with moisturizers/ceramides and systematic emollient routines [13,37]. In neonates, mild formulations at pH ~5.5 show better compatibility than traditional soaps [29].

Methodologically, the literature agrees that no single marker fully captures barrier function. The combination of TEWL, pH, corneometry, and erythema constitutes the "minimum common" for evaluation, and complementary techniques (e.g., mCMS/CIM, tape stripping with IL-1α/IL-1Ra, and, when available, confocal Raman spectroscopy) add granularity and sensitivity for lesions [7,10,22,31].

Finally, the review of "antibacterial" soaps qualifies their use: agents such as triclosan do not offer proven clinical superiority over syndets and carry dermatological and dysbiosis risks; their replacement with alternatives with a better safety profile is consistent with regulatory and dermatological recommendations [32].

LIMITATIONS

This review is narrative and, by design, does not incorporate meta-analysis or quantitative effect assessment. Heterogeneity between studies due to product type (soap, syndet, moisturizer, ABHR), anatomical areas, usage pattern, intervention duration, and measurement panel (TEWL, pH, corneometry, erythema, biomarkers) limits direct comparability and inferential strength.

Most trials include short-term exposures in healthy volunteers, which restricts extrapolation to patients with dermatoses (e.g., atopic dermatitis) or chronic occupational exposures. Several studies do not comprehensively control environmental variables (temperature, relative humidity) or standardize friction/contact time, with a risk of residual confounding. Although TEWL and pH are sensitive, they do not fully capture neurocutaneous phenomena (pruritus) or dysbiosis; advanced techniques (mCMS, Raman, tape stripping) are not yet universally used, hindering inter-study triangulation.

Furthermore, the time frame (last 10 years) and the filtering of studies in humans may have excluded valuable prior evidence or relevant mechanistic data. All of this suggests that the results should be interpreted with caution and reinforces the need for longer, standardized comparative trials in vulnerable populations.

DERMATOLOGICAL RECOMMENDATIONS

The accumulated evidence on the impact of cleansing agents on the skin barrier function allows us to establish a set of clinical guidelines focused on preventing irritant contact dermatitis (ICD) and preserving epidermal integrity.

1. **Cleansing Agent Selection**

The choice of cleanser should prioritize minimizing structural and biochemical damage to the stratum corneum (SC).

- ***Priority to physiological pH:*** The use of cleansers with a subacid or physiological pH (4.5–6.0), such as syndets, is recommended, as they prevent the transient alkalization of the skin, which has been shown to increase skin permeability [6].
- ***Avoid harsh surfactants:*** Alkaline soaps and those formulated with strong anionic surfactants should be avoided, especially on sensitive or

compromised skin. SLS is a known irritant that disrupts the skin barrier function by denaturing proteins and extracting epidermal lipids [1,15].

- ***Alternatives in intensive hygiene:*** In healthcare or intensive hygiene settings, hydroalcoholic solutions with emollients cause less disruption of the skin barrier than repeated washing with soap [38]. Furthermore, the use of ethanol-based disinfectants containing urea can reduce soap sensitivity [36].

2. **Modification of Hygiene Practices**

Cleansing technique and frequency should be optimized to reduce mechanical and chemical stress.

- ***Limiting Exposure:*** Repeated exposure to detergents and excessive washing, even with mild products, are correlated with barrier impairment and reduced skin barrier function [39]. Limiting the frequency and duration of contact with water and cleanser is recommended.
- ***Minimizing Friction:*** Mechanical manipulation during washing contributes to barrier damage. Cleaning procedures should be brief and gentle, avoiding unnecessary friction [24].
- ***Occlusion Management:*** In occupational settings, prolonged occlusion with gloves exacerbates detergent-induced damage [9]. Limiting the wear time of impermeable gloves and applying skin protection measures are recommended.

3. **Repair and Protection Strategies**

Active barrier repair is an essential component of prevention.

- ***Post-wash emollience:*** Immediate application of emollients is crucial to counteract the increase in TEWL and restore barrier integrity [37]. Moisturizers containing physiological lipids or NMF are preferred.
- ***Care in the elderly:*** In the geriatric population, it is essential to avoid alkaline soaps and use daily moisturizing cleansers and emollients to maintain epidermal integrity and reduce the risk of fissures and dermatitis [40].
- ***Susceptibility monitoring:*** Individual susceptibility to irritative damage can be assessed using structural biomarkers such as corneocytic nanotexture, allowing identification of individuals at higher risk of developing ICD [41].

CONCLUSIONS

Alkaline soaps with anionic surfactants (e.g., SLS) consistently disrupt the barrier function of the stratum corneum: they raise the pH, extract lipids, and increase TEWL, facilitating inflammation and irritant dermatitis. In contrast, syndets with a physiological pH and moisturizing cleansers show better dermatological compatibility and less impact on pH/TEWL, especially when friction and contact time are reduced. In intensive hygiene settings, alternating washing with ABHR soaps containing emollients, plus immediate emollience after each cleansing, effectively mitigates the cumulative effect of these irritations.

The regimen should be individualized according to skin type, age, skin comorbidities, and exposure (wet work/occlusion).

Looking ahead, pragmatic, long-term trials are needed to compare formulations under real-world conditions (frequency, friction, occlusion, temperature), with standardized outcome panels (TEWL, pH, corneometry, erythema, mCMS/CIM, and biomarkers by tape stripping), inclusion of vulnerable subgroups (atopic dermatitis, older adults, healthcare workers), and clinically significant outcomes (symptoms, flares, adherence, quality of life). In the meantime, the clinical recommendation is clear: favor syndets or moisturizing cleansers at pH 4.5–5.5, minimize friction and contact time, alternate with emollient ABHR cleansers when appropriate, and apply emollients after each cleansing to preserve skin barrier homeostasis.

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Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

REFERENCES

1. Angelova-Fischer I, Hoek AK, Dapic I, Jakasa I, Kezic S, Fischer TW, et al. Barrier function and natural moisturizing factor levels after cumulative exposure to a fruit-derived organic acid and a detergent: different outcomes in atopic and healthy skin and relevance for occupational contact dermatitis in the food industry. Contact Dermatitis. diciembre de 2015;73(6):358–63.
2. Tan SW, Oh CC. Contact Dermatitis from Hand Hygiene Practices in the COVID-19 Pandemic. Ann Acad Med Singap. septiembre de 2020;49(9):674–6.
3. Rundle CW, Presley CL, Militello M, Barber C, Powell DL, Jacob SE, et al. Hand hygiene during COVID-19: Recommendations from the American Contact Dermatitis Society. J Am Acad Dermatol. diciembre de 2020;83(6):1730–7.
4. Gina M, Wichert K, Kutz G, Brüning T, Fartasch M. Applying skin protective cream and the wearing of gloves?-A randomized controlled experimental study. Contact Dermatitis. mayo de 2023;88(5):372–82.
5. Abdollahi H, Ghanbarlou S, Babapoor A, Yari Kalashgarani M, Valadez I, Zarrintaj P, et al. Surfactant-containing detergents: Impacts on dermal health. Colloids Surf B Biointerfaces. diciembre de 2025;256(Pt 1):115026.

6. Koudounas S, Bader DL, Voegeli D. Elevated Skin pH Is Associated With an Increased Permeability to Synthetic Urine. J Wound Ostomy Continence Nurs. el 1 de febrero de 2021;48(1):61–7.
7. Hawkins S, Dasgupta BR, Ananthapadmanabhan KP. Role of pH in skin cleansing. Int J Cosmet Sci. agosto de 2021;43(4):474–83.
8. Uta D, Inami Y, Fukushima M, Kume T. Light-Touch-Induced Afterdischarge Firing in the Superficial Spinal Dorsal Horn Neurons in Hairless Mice with Irritant Contact Dermatitis. Biol Pharm Bull. 2022;45(11):1678–83.
9. Higgins CL, Palmer AM, Cahill JL, Nixon RL. Occupational skin disease among Australian healthcare workers: a retrospective analysis from an occupational dermatology clinic, 1993-2014. Contact Dermatitis. octubre de 2016;75(4):213–22.
10. Alsamad F, Stamatas GN. Directional assessment of the skin barrier function in vivo. Skin Res Technol. mayo de 2023;29(5):e13346.
11. Dąbrowska AK, Spano F, Derler S, Adlhart C, Spencer ND, Rossi RM. The relationship between skin function, barrier properties, and body-dependent factors. Skin Res Technol. mayo de 2018;24(2):165–74.
12. Ananthapadmanabhan KP, Leyden JJ, Hawkins SS. Recent Advances in Mild and Moisturizing Cleansers. J Drugs Dermatol. el 1 de enero de 2019;18(1s):s80-88.
13. Lichterfeld-Kottner A, El Genedy M, Lahmann N, Blume-Peytavi U, Büscher A, Kottner J. Maintaining skin integrity in the aged: A systematic review. Int J Nurs Stud. marzo de 2020;103:103509.
14. Tamagawa-Mineoka R, Katoh N. Atopic Dermatitis: Identification and Management of Complicating Factors. Int J Mol Sci. el 11 de abril de 2020;21(8).
15. Lain E, Andriessen AE. Choosing the Right Partner: Complementing Prescription Acne Medication With Over-the-Counter Cleansers and Moisturizers. J Drugs Dermatol. el 1 de noviembre de 2020;19(11):1069–75.
16. Presley CL, Militello M, Barber C, Ladd R, Laughter M, Ferguson H, et al. The History of Surfactants and Review of Their Allergic and Irritant Properties. Dermatitis. el 1 de octubre de 2021;32(5):289–97.
17. Khosrowpour Z, Ahmad Nasrollahi S, Samadi A, Ayatollahi A, Shamsipour M, Rajabi-Esterabadi A, et al. Skin biophysical assessments of four types of soaps by forearm in-use test. J Cosmet Dermatol. julio de 2022;21(7):3127–32.
18. Castanedo-Cázares JP, Cortés-García JD, Cornejo-Guerrero MF, Torres-Álvarez B, Hernández-Blanco D. Study of the cytotoxic and irritant effects of skin cleansing soaps. Gac Med Mex. 2020;156(5):418–23.
19. Khosrowpour Z, Ahmad Nasrollahi S, Ayatollahi A, Samadi A, Firooz A. Effects of four soaps on skin trans-epidermal water loss and erythema index. J Cosmet Dermatol. junio de 2019;18(3):857–61.
20. Salomon G, Giordano-Labadie F. Surfactant irritations and allergies. Eur J Dermatol. 2022;32(6):677–81.
21. Jacobsen G, Rasmussen K, Bregnhøj A, Isaksson M, Diepgen TL, Carstensen O. Causes of irritant contact dermatitis after occupational skin exposure: a systematic review. Int Arch Occup Environ Health. enero de 2022;95(1):35–65.
22. Symanzik C, Kezic S, Jakasa I, Skudlik C, John SM, Brans R, et al. Effects of skin washing frequency on the epidermal barrier function and inflammatory processes of the epidermis: An experimental study. Contact Dermatitis. septiembre de 2022;87(3):241–6.
23. Tiedemann D, Clausen ML, John SM, Angelova-Fischer I, Kezic S, Agner T. Effect of glove occlusion on the skin barrier. Contact Dermatitis. enero de 2016;74(1):2–10.
24. Gina M, Wichert K, Pieper B, Behrens T, Brüning T, Fartasch M. Irritant potential of different washing procedures used for heavy-duty soiling: Short and intense or longer and mild? Contact Dermatitis. mayo de 2023;88(5):363–71.
25. Fartasch M. Wet Work and Barrier Function. Curr Probl Dermatol. 2016;49:144–51.
26. Lauriola MM, Corazza M. Dermato-allergological risks in beauty operators. Ital J Dermatol Venerol. junio de 2023;158(3):243–8.
27. Warshaw EM, Ruggiero JL, Atwater AR, DeKoven JG, Zug KA, Reeder MJ, et al. Occupational Contact Dermatitis in Dental Personnel: A Retrospective Analysis of the North American Contact Dermatitis Group Data, 2001 to 2018. Dermatitis. el 1 de febrero de 2022;33(1):80–90.
28. Cahill JL, Williams JD, Matheson MC, Palmer AM, Burgess JA, Dharmage SC, et al. Occupational skin disease in Victoria, Australia. Australas J Dermatol. mayo de 2016;57(2):108–14.
29. Amer M, Diab N, Soliman M, Amer A. Neonatal skin care: what should we do? A four-week follow-up randomized controlled trial at Zagazig University Hospitals. Int J Dermatol. noviembre de 2017;56(11):1198–203.
30. Lodén M. Ethanol-Based Disinfectants Containing Urea May Reduce Soap Sensitivity. Dermatitis. octubre de 2020;31(5):328–32.
31. Liu M, Mollica L, Regan J, Hawkins S, McGuiness H, Vetro K, et al. Modified Corneosurfametry as a new accelerated high-throughput ex vivo methodology for predicting cleanser effects towards human skin. Int J Cosmet Sci. abril de 2016;38(2):178–86.
32. Rundle CW, Hu S, Presley CL, Dunnick CA. Triclosen and Its Alternatives in Antibacterial Soaps. Dermatitis. diciembre de 2019;30(6):352–7.
33. Tasar R, Wiegand C, Elsner P. How irritant are n-propanol and isopropanol? - A systematic review. Contact Dermatitis. enero de 2021;84(1):1–14.
34. Japundžić I, Novak-Hlebar I, Špiljak B, Kuna M, Yale K, Lugović-Mihić L. SKIN FEATURES IMPORTANT FOR THE OCCURRENCE OF CONTACT DERMATITIS IN HEALTHCARE WORKERS. Acta Clin Croat. diciembre de 2022;61(4):692–702.
35. Chopin-Doroteo M, Krötzsch E. Soap or alcohol-based products? The effect of hand hygiene on skin characteristics during the COVID-19 pandemic. J Cosmet Dermatol. febrero de 2023;22(2):347–53.

36. Jordan L. Efficacy of a Hand Regimen in Skin Barrier Protection in Individuals With Occupational Irritant Contact Dermatitis. J Drugs Dermatol. el 1 de noviembre de 2016;15(11):s81–5.
37. Cowdell F, Jadotte YT, Ersser SJ, Danby S, Lawton S, Roberts A, et al. Hygiene and emollient interventions for maintaining skin integrity in older people in hospital and residential care settings. Cochrane Database Syst Rev. el 23 de enero de 2020;1(1):CD011377.
38. Appelen D, Romijn-Bucarciuc D, Stenveld H, Visch MB. [Hand eczema in COVID-19 outbreak: whether or not to wear gloves?]. Ned Tijdschr Geneeskd. el 5 de noviembre de 2020;164:D5252.
39. Angelova-Fischer I, Stilla T, Kezic S, Fischer TW, Zillikens D. Barrier Function and Natural Moisturizing Factor Levels After Cumula-tive Exposure to Short-chain Aliphatic Alcohols and Detergents: Results of Occlusion-modified Tandem Repeated Irritation Test. Acta Derm Venereol. el 2 de noviembre de 2016;96(7):880–4.
40. MacGibeny MA, Wassef C. Preventing adverse cutaneous reactions from amplified hygiene practices during the COVID-19 pandemic: how dermatologists can help through anticipatory guidance. Arch Dermatol Res. agosto de 2021;313(6):501–3.
41. Rüther L, Kezic S, Riethmüller C. Corneocyte Nanotexture as Biomarker for Individual Susceptibility to Skin Irritants. Ann Work Expo Health. el 3 de marzo de 2021;65(2):201–5.

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Atrial Fibrillation: Basic Concepts and Clinical Considerations

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ABSTRACT

This article aims to provide an updated and comprehensive review of atrial fibrillation (AF), addressing its pathophysiological basis, clinical aspects, diagnosis, and treatment strategies to improve knowledge among both healthcare professionals and the general public.

AF is the most common sustained arrhythmia in adults, affecting 2-3% of the world's population. This work describes how the disorganization of atrial electrical discharges disrupts the normal heart rhythm, analyzing risk factors such as hypertension, age, and pre-existing cardiovascular disease. It details that the primary diagnosis is made via electrocardiogram, identifying the absence of P waves and irregular RR intervals for at least 30 seconds. Finally, therapeutic options focused on arrhythmia control and thromboembolism prevention through the use of anticoagulants are explored.

Early diagnosis and comprehensive management are essential to reduce associated morbidity and mortality, prevent serious complications such as strokes, and significantly improve patients' quality of life.

Keywords: atrial fibrillation, cardiac arrhythmia, electrocardiogram.

INTRODUCTION

Atrial fibrillation is a common heart condition, affecting millions of people worldwide. The importance of understanding atrial fibrillation lies in its high prevalence and serious health implications. It affects 2-3% of the world's population, with a trend toward increasing prevalence due to aging. In addition to the risk of stroke, it is associated with chronic fatigue and other complications if not treated promptly [1].

This article addresses clinical and pathophysiological aspects, available treatments, medical innovations, the socioeconomic impact, and prevention strategies.

Its aim is to provide a clear and up-to-date understanding, not only for healthcare professionals but also for those who wish to better understand this cardiovascular condition and its impact on daily life.

ATRIAL FIBRILLATION

Atrial fibrillation is a condition that affects the heart rhythm. It is characterized by irregular and rapid heartbeats originating in the atria instead of a normal rhythm.

In a person with AF, the electrical impulses in the atria that cause the heartbeat become asynchronous and disorganized, resulting in fibrillation. Atrial fibrillation can be caused by various factors (age, pre-existing heart conditions, high blood pressure, lung disease, excessive alcohol consumption, genetic factors, etc.) and can increase the risk of serious complications such as stroke (vascular disease) due to blood clots forming within the heart, as well as heart failure and other heart conditions.

AF has a significant impact on people's daily lives, both for those who suffer from it and for their families and society in general, for several reasons. It can affect quality of life, as symptoms such as palpitations, fatigue, and shortness of breath, among others, can be debilitating and very bothersome. Similarly, the depression and anxiety that can accompany AF often have psychological repercussions.

These patients are often advised to make lifestyle changes, such as reducing alcohol and tobacco consumption, adopting a healthier diet, and avoiding stressful situations. This involves making adjustments and modifications to their routines that can be difficult to manage.

Likewise, AF has also increased awareness about cardiovascular health in society; people may be more aware of the importance of controlling their blood pressure, maintaining a healthy weight according to their needs, and leading an active lifestyle to reduce the risk of developing AF or other heart conditions.

In summary, atrial fibrillation is a condition that has repercussions on the physical and mental health of those who suffer from it, so it is important to know the correct management and treatment of this disease along with the complications it can have, so that we can minimize its impact and improve the quality of life of patients.

ETIOLOGY

Atrial fibrillation is considered a multifactorial condition, as its exact etiology is still unknown. However, several factors are closely associated with an increased risk of its development.

In developed countries, AF is associated with coronary artery disease and hypertensive heart disease. Hypertension is the most frequent underlying cause of atrial fibrillation, while coronary artery disease does not cause AF unless it is complicated by an acute myocardial infarction, which can lead to the condition due to ischemia or atrial dilation secondary to heart failure (HF).

Likewise, any valvular disease that causes stenosis or regurgitation can be directly related to AF.

Heart failure and atrial fibrillation can occur simultaneously, and the incidence of AF generally increases considerably in those with more advanced HF. Atrial fibrillation is also associated with congenital heart disease involving the atria; however, it can be related to other conditions such as Ebstein's anomaly, pulmonary stenosis, or ventricular septal defects.

Patients with cardiopulmonary diseases such as COPD, dilated cardiomyopathy, pericarditis (idiopathic or uremic), or obstructive sleep apnea syndrome (OSAS) have a higher risk of developing AF.

Chronic kidney disease is a significant risk factor for the development of AF, as the risk increases by approximately 32% in patients with a glomerular filtration rate (GFR) between 30 and 59 ml/min [2] compared to those with normal kidney function. Another associated factor is diabetes mellitus, with an increased risk of 10% in men and 50% in women [2].

An increased incidence of AF has been observed in patients undergoing cardiac surgery, with combined coronary artery bypass grafting (CABG) surgery carrying the highest increased risk for AF (60%) [2]. In patients with atrial fibrillation of unknown cause, it is important to measure thyrotropin levels, as the incidence of atrial fibrillation in patients with hyperthyroidism can reach 10–20% in adults over 60 years of age, with a higher frequency in men [2].

In conclusion, the main comorbidities associated with atrial fibrillation include: hypertension, ischemic heart disease, heart failure, diabetes mellitus, chronic kidney disease, and chronic obstructive pulmonary disease.

PATHOPHYSIOLOGY

Atrial fibrillation can occur in patients with or without structural heart disease. The latter is primarily caused by electrical abnormalities, triggered by electrical factors. These triggers are multiple foci of microreentry in the atrium.

The pathogenesis is not fully understood and is considered multifactorial; however, two components play an important role: a triggering factor and the anatomical substrate that favors the maintenance of the arrhythmia.

- **Triggering Factors**

These are associated with structural and electrophysiological abnormalities that promote the formation and propagation of abnormal impulses; in short, they function as "triggers" [3].

Most of the initiating foci are located in the pulmonary veins. At the junction of the left atrium and the pulmonary veins, there is a significant overlap of muscle fibers, making the veins thicker in their proximal portion and thus creating highly heterogeneous tissue. This results in a complex organization of muscle fibers, acting as a trigger [3].

- **Maintenance Mechanism**

Once AF has begun, several factors maintain this arrhythmia, such as the persistence of the arrhythmogenic discharge. In the absence of triggering foci, remodeling of the conduction and structural system can occur, leading to atrial dilation and shortening of the refractory period. These two factors can be part of the natural history of the disease or act as triggers.

- **Substrate**

AF often accompanies other systemic diseases such as hypertension, ischemic heart disease, heart failure, and hyperthyroidism. These comorbidities trigger an atrial adaptive response to maintain homeostasis. The main consequences of this response are chamber dilation and fibrosis.

These adaptive mechanisms are important in the development of AF. The aging process itself generates changes in electrical conduction, which also contributes as a substrate for the development of AF, whose progression is accelerated by the aforementioned comorbidities.

- **Inflammation**

There is evidence that inflammation of myocardial tissue is key in the pathogenesis of AF [3].

Furthermore, inflammation may be a consequence of AF, creating a vicious cycle where inflammation produces AF and the disease itself induces a greater inflammatory response.

In summary, in atrial fibrillation, the atrium loses its ability to contract due to triggering foci that cause atrial fibrillation. Over time, the resulting dilation and fibrosis further modify the myocardium and electrical conduction, perpetuating the condition.

The absence of normal contraction promotes a prothrombotic state due to blood stasis within the heart chambers, thus promoting clot formation. These clots can subsequently embolize into the systemic circulation, causing ischemic events. This is important because stroke is the main complication of AF, and its prevention is a cornerstone of disease management.

EPIDEMIOLOGY

Atrial fibrillation is the most common sustained arrhythmia in adults and is associated with significantly higher morbidity and mortality, making it important for both patients and healthcare systems.

The prevalence of AF in adults is 2-4% and is anticipated to increase 2-3 times [2]. Aging is a risk factor for AF, as are other comorbidities such as hypertension, diabetes mellitus, heart failure, coronary artery disease, chronic kidney disease, obesity, and obstructive sleep apnea.

The incidence, prevalence, and lifetime risk rates of AF are lower in women than in men. The lifetime risk of developing AF is estimated at 1 in 3 individuals of European descent by age 55.

The impact of AF and its association with other comorbidities indicate that early intervention and control of risk factors could reduce the incidence of AF.

CLINICAL MANIFESTATIONS

50-87% of patients with atrial fibrillation are initially asymptomatic, which can hinder timely diagnosis and lead to a less favorable prognosis. Those who do experience signs and symptoms often present with:

- Palpitations.
- Shortness of breath.
- Fatigue.
- Chest pain or pressure.
- Poor exercise tolerance.
- Dizziness.
- Syncope.
- Sleep disturbances.
- Anxiety and depression.

More than 60% of patients with AF experience a significant decline in their quality of life, although only 17% suffer disabling symptoms. This decline is more pronounced in women, younger individuals, and those with comorbidities.

In addition to the typical signs and symptoms, hemodynamically unstable individuals may present with more significant clinical manifestations:

- Symptomatic hypotension.
- Acute heart failure with or without pulmonary edema.
- Developing myocardial ischemia.
- Cardiogenic shock.

DIAGNOSIS

Early diagnosis of atrial fibrillation is important, as the condition can be asymptomatic or the symptoms can be mild. Some people experience palpitations, shortness of breath, fatigue, or dizziness, but in other cases, AF may not present any symptoms until a complication arises. Therefore, early diagnosis allows for the initiation of appropriate treatment to prevent complications and, sometimes, even reverse the arrhythmia.

According to the European Society of Cardiology (ESC) guidelines, diagnosis requires electrocardiogram documentation of an AF episode that must last at least 30 seconds and show a loss of P waves and irregular RR intervals (Figure 1).

Additionally, several tools are available to help complete the diagnosis (Table 1).



Figure 1. Electrocardiogram with absence of P waves and irregular RR intervals.

CLASSIFICATION

According to the European Society of Cardiology guidelines, atrial fibrillation is complex and presents in various forms, both in patients with heart disease and in apparently healthy individuals.

The classification of AF involves terms such as "lone AF" and "idiopathic AF," and these can be differentiated. Lone AF refers to the onset of the arrhythmia in individuals under 60 years of age who do not present with clinical or echocardiographic manifestations of any other disease. These individuals generally have a more favorable prognosis regarding common AF complications, such as the risk of blood clots and mortality. However, either due to the passage of time or because signs of heart disease begin to appear, these patients will no longer be considered to have lone AF, and therefore, the risk of complications will increase.

Idiopathic atrial fibrillation implies a lack of certainty regarding its origin, regardless of age or the presence of any underlying cardiovascular problem.

The recommended classification for AF focuses on clinical relevance. A distinction is made between the first detected episode of AF, whether symptomatic or brief, and recurrent episodes. Recurrent episodes are divided into paroxysmal AF, when the arrhythmia stops spontaneously or with intervention within 7 days of onset, and persistent AF, when it lasts for more than 7 days and requires cardioversion to terminate.

Persistent AF can be the first presentation or the result of uncontrolled recurrent episodes. Furthermore, long-standing persistent AF is defined as AF that continues for more than 1 year even after the use of heart rhythm control strategies.

Permanent AF is considered to be AF that persists long-term without attempts at reversion.

It is crucial to differentiate secondary AF, which occurs as a result of a triggering condition, such as a heart attack, cardiac surgery, or other diseases. Treating the underlying condition, along with controlling AF, usually leads to AF elimination.

Table 1. Diagnostic tools for AF, as a complement to the electrocardiogram, for classification and therapeutic management.

Diagnostic tool	Description
Medical history	Collects the patient's medical history, symptoms, risk factors, triggers, and the type of atrial fibrillation.
Physical examination	Looks for pulse irregularity, presence of heart murmurs, edema, or signs of heart failure.
Holter monitor	Portable electrocardiogram that continuously records the heart's electrical activity for 24 to 48 hours or more. Looks for episodes of irregular heart rhythm.
Event recorder	Records specific episodes. However, instead of recording continuously, it is activated manually. It is useful in patients with infrequent episodes.
Implantable loop recorder	Implanted under the skin, it continuously monitors cardiac activity for up to 3 years. It activates automatically when it detects changes in heart rhythm.
Echocardiogram	Implantation method that can show structural abnormalities, cardiac function, and the presence of blood clots in the atria.
Stress test	It allows us to evaluate the heart's response to physical exertion. It helps us determine if atrial fibrillation develops or worsens with exercise.
Chest X-ray	The findings can vary, and there are no pathognomonic findings for AF, but some patients may present with: atrial enlargement, signs of heart failure, visible clots as opacities, and areas of pulmonary consolidation.

As can be seen, the ESC classification is based on the duration of episodes and the presence or absence of triggers and is extremely important for managing AF, as treatment must be individualized (Table 2).

TREATMENT

The pharmacological treatment of AF is based on two key objectives: the prevention of embolism through anticoagulation and the control of the arrhythmia.

- **Pharmacological Treatment Focused on Thromboembolism Prevention**

Regarding the first objective, vitamin K antagonists (VKAs) have been shown to be more effective in reducing embolic risk, while acetylsalicylic acid (ASA) lacks significant benefits. New oral anticoagulants (NOACs) such as dabigatran, rivaroxaban, apixaban, and edoxaban have proven to be favorable options for the prophylactic treatment of patients with atrial fibrillation.

VKAs have been a key element in reducing embolic strokes in patients with AF of all types; however, NOACs have shown promise in the current context. The reduction in the incidence of cerebral bleeding (estimated to be 2 to 3 times lower than with VKAs) and a higher rate of treatment adherence are some of the determining factors for initiating anticoagulation with a NOAC instead of a VKA as the first-line treatment.

- **Antiarrhythmic Treatment**

Choosing the right antiarrhythmic drug is a fundamental pillar in the management of patients with atrial fibrillation. This decision must be made considering several relevant factors, such as the type of arrhythmia, the progression of the disease, associated heart conditions, the patient's medical history, comorbidities, and the antiarrhythmic's safety profile.

The Spanish Journal of Cardiology offers an overview of recommended drugs based on some of the aforementioned criteria, as well as the non-pharmacological strategies employed depending on the context (summarized in Tables 3, 4, 5, and 6).

Table 2. Classification of AF according to the 2020 ESC guidelines.

AF Pattern	Description
AF diagnosed for the first time	AF has not been previously diagnosed, regardless of the duration of the arrhythmia or the presence and severity of related symptoms.
Paroxysmal AF	AF resolves spontaneously or with intervention within the first 7 days.
Persistent AF	AF persists for more than 7 days, including episodes terminated by pharmacological or electrical cardioversion after more than 7 days.
Long-standing persistent AF	AF continues for more than 1 year after a cardiac rhythm control strategy is implemented.
Permanent FA	The patient and physician accept the AF, and no further measures are taken to restore or maintain sinus rhythm.**
Terminology to Avoid	
Isolated AF	Advances in the understanding of AF pathophysiology show that there is a specific cause for AF in each patient. Therefore, this historical terminology can be misleading and should not be used.
Valvular / Non-valvular AF	It differentiates patients with moderate/severe mitral stenosis or mechanical heart valves from other patients with AF, but it can be confusing and should not be used.
Chronic AF	It has several definitions and should not be used to describe populations of patients with AF.

***Permanent AF represents more of a therapeutic approach by the patient and physician than an inherent pathophysiological attribute of AF. This term should not be used in the context of a rhythm control strategy with antiarrhythmic drugs or catheter ablation. If rhythm control measures are implemented, the arrhythmia would be reclassified as "long-standing persistent AF."*

EXAMPLES AND METAPHORS

To better understand what happens when there is atrial fibrillation, we can imagine that the heart is like a group of people dancing a choreographed routine.

Like in any dance group, there is a choreographer who guides everyone and tells them how to move so that everything goes well and everyone follows the correct steps. The choreographer is the sinoatrial node. However, in atrial fibrillation, the choreographer is impaired and cannot tell them how or where to move, so the dancers begin to dance without coordination. Some get ahead, some fall behind, and some make mistakes. Therefore, the choreography is disorganized, uncoordinated, full of errors, and becomes chaotic.

Another example to better understand what happens in people with AF is to imagine that the heart is like a person driving a manual car and trying to start the car and maintain a constant speed. To do this, the driver must first press the clutch and then the accelerator pedal. Therefore, in AF, the driver begins to release the clutch pedal while simultaneously pressing the accelerator, then presses both pedals at the same time, then presses neither. This causes the car to not maintain a constant speed and may even stall.

KEY POINTS AND CONCLUSION

Atrial fibrillation (AF) is a common heart condition, affecting approximately 2-3% of the world's population. The importance of understanding atrial fibrillation lies in its high prevalence and serious health implications, which include, but are not limited to, chronic fatigue and an increased risk of stroke.

AF is a condition characterized by irregular and rapid heartbeats originating in the atria instead of a normal rhythm. The electrical discharges in the atria that generate the heartbeat become asynchronous and disorganized, resulting in fibrillation. There are several risk factors and predisposing factors for atrial fibrillation, such as a history of previous heart disease, high blood pressure, lung disease, age, and some modifiable factors, such as excessive alcohol consumption.

It is considered a multifactorial condition, and its exact etiology is unknown. However, there are factors closely associated with an increased risk of its incidence. The main comorbidities related to atrial fibrillation include hypertension, ischemic heart disease, heart failure, diabetes mellitus, chronic kidney disease, and chronic obstructive pulmonary disease.

Early diagnosis allows for the initiation of appropriate treatment to prevent complications and, in some cases, reverse the arrhythmia. Although the electrocardiogram is the primary method for diagnosing AF, there are additional tools that support the confirmation of the diagnosis, such as medical history, physical examination, Holter monitor, echocardiogram, and chest X-ray, among others.

Atrial fibrillation is the most common sustained arrhythmia in adults and is associated with significantly higher morbidity and mortality, making it important for both patients and healthcare systems. It is a condition that has repercussions on the physical and mental health of those who suffer from it.

Table 3. Comprehensive therapeutic approach to atrial fibrillation according to the 2020 ESC guidelines.

Therapeutic Aim	Initial Assessment	Initial Interventions
Prevention of Thromboembolic Events	Collect the patient's medical history, symptoms, risk factors, triggers, and type of AF.	Oral anticoagulation with direct oral anticoagulants or vitamin K antagonists, depending on the patient's characteristics.
Symptom Control	Determine clinical impact based on symptoms, ventricular rate, and type of AF.	Heart-rate control or rhythm control strategy, depending on individual characteristics.
Cardiovascular Optimization and Comorbidities	Identify factors associated with AF progression.	Manage hypertension, obesity, diabetes, obstructive sleep apnea, sedentary lifestyle, smoking, and alcohol consumption.

Table 4. Pharmacological treatment of atrial fibrillation according to therapeutic objective according to the 2020 ESC guidelines.

Aim	Pharmacological Group	Main Drugs	Considerations
Prevention of Thromboembolic Events	Direct Oral Anticoagulants	Apixaban, dabigatran, edoxaban, rivaroxaban	Preferred over vitamin K antagonists in most eligible patients.
	Vitamin K Antagonists	Warfarin	Indicated primarily in mechanical valves or significant mitral stenosis.
Heart-rate Control	β-blockers	Metoprolol, bisoprolol, carvedilol.	Frequent first-line treatment; especially useful in patients with ischemic heart disease or heart failure.
	Non-dihydropyridine Calcium Channel Blockers	Diltiazem, verapamil.	Useful in patients with preserved ventricular function; avoid in heart failure with reduced ejection fraction.
	Cardiac Glycosides	Digoxin	Can be used particularly in sedentary patients or those with heart failure.
Rhythm Control	Antiarrhythmic Drugs to Restore and Maintain Sinus Rhythm		Drug selection depends on the presence of structural heart disease and associated comorbidities. The main antiarrhythmics and their indications are described in Table 5.

Table 5. Antiarrhythmic drugs for rhythm control in atrial fibrillation according to patient clinical characteristics, according to the 2020 ESC guidelines.

Drug	Vaughan-Williams Class	Candidate Patient	Considerations
Flecainide	Class IC (sodium channel blocker)	Atrial fibrillation (AF) in patients without significant structural heart disease.	Avoid in coronary artery disease, left ventricular dysfunction, or significant ventricular hypertrophy due to proarrhythmic risk.
Propafenone	Class IC (sodium channel blocker with mild β-blocking activity)		Same restrictions as flecainide; It can be combined with AV node blocking agents to prevent 1:1 conduction of atrial flutter.
Dronedarone	Class III (multichannel blocker: K^+, Na^+, and Ca^{2+})	Paroxysmal or persistent AF in selected patients without advanced heart failure.	Less effective than amiodarone; contraindicated in heart failure with severe ventricular dysfunction or permanent atrial fibrillation.
Sotalol	Class III (potassium channel blocker with β-blocking activity)	Selected patients with preserved ventricular function.	Requires monitoring of the QT interval due to the risk of *torsades de pointes*.
Amiodarone	Class III (multichannel blocker)	Patients with structural heart disease, heart failure, or when other antiarrhythmics are not suitable.	Highly effective for maintaining sinus rhythm; limited by pulmonary, thyroid, hepatic, and ocular toxicity.

Table 6. Non-pharmacological strategies for restoration and maintenance of sinus rhythm according to the 2020 ESC guidelines.

Strategy	General Indications	Key Aspects
Electrical Cardioversion	Symptomatic patients, hemodynamic instability, or need for rapid restoration of sinus rhythm.	Greater immediate efficacy compared to pharmacological cardioversion.
Catheter Ablation	Selected symptomatic patients with paroxysmal or persistent AF.	May be superior to antiarrhythmics for maintaining sinus rhythm in certain patients.
Modification of Risk Factors	All patients with AF.	Weight reduction, physical activity, management of sleep apnea, hypertension, and alcohol consumption.

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Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

REFERENCES

1. Westerman S, Wenger N. Gender differences in atrial fibrillation: A review of epidemiology, management, and outcomes. Curr Cardiol Rev [Internet]. 2019 [citado el 18 de octubre de 2023];15(2):136–44. Disponible en: http://dx.doi.org/10.2174/1573403x15666181205110624
2. Kornej J, Börschel CS, Benjamin EJ, Schnabel RB. Epidemiology of atrial fibrillation in the 21st century: Novel methods and new insights. Circ Res [Internet]. 2020 [citado el 18 de octubre de 2023];127(1):4–20. Disponible en: http://dx.doi.org/10.1161/circresaha.120.316340
3. Sagris M, Vardas EP, Theofilis P, Antonopoulos AS, Oikonomou E, Tousoulis D. Atrial fibrillation: Pathogenesis, predisposing factors, and genetics. Int J Mol Sci [Internet]. 2021 [citado el 18 de octubre de 2023];23(1):6. Disponible en: https://www.mdpi.com/1422- 0067/23/1/6
4. Chyou JY, Barkoudah E, Dukes JW, Goldstein LB, Joglar JA, Lee AM, et al. Atrial fibrillation occurring during acute hospitalization: A scientific statement from the 3 American heart association. Circulation [Internet]. 2023 [citado el 18 de octubre de 2023];147(15). Disponible en: http://dx.doi.org/10.1161/cir.0000000000001133
5. Jame S, Barnes G. Stroke and thromboembolism prevention in atrial fibrillation. Heart [Internet]. 2020 [citado el 18 de octubre de 2023];106(1):10–7. Disponible en: http://dx.doi.org/10.1136/heartjnl-2019-314898
6. Aronow WS. Atrial fibrillation and thromboembolic stroke. Compr Ther [Internet]. 1994 [citado el 18 de octubre de 2023];20(3). Disponible en: https://pubmed.ncbi.nlm.nih.gov/8187461/
7. Heart Foundation. What is atrial fibrillation? [Internet]. 2020 [citado el 18 de octubre de 2023]; Disponible en: https://youtu.be/UOkseyF-wrA?si=nOttGq3swJzb1Z0t
8. Revista Española de Cardiología. Tratamiento farmacológico de la fibrilación auricular. Antiarrítmicos y Anticoagulantes Orales [Internet]. 2016 [citado el 18 de octubre de 2023]; Disponible en: https://www.revespcardiol.org/es-tratamiento-farmacologico-fibrilacion-auricular-antiarritmicos-articulo-S1131358716300127

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Chagas Disease: Epidemiology, Diagnosis and Treatment in Mexico

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ABSTRACT

The article describes the etiology of Chagas disease, caused by the parasite *Trypanosoma cruzi*, and its transmission through vectors known as kissing bugs. The phases of the disease are detailed: acute (generally asymptomatic), indeterminate, and chronic. Serious complications such as Chagas cardiomyopathy, characterized by myocardial damage and fibrosis, and colonopathy are also analyzed. The article reviews direct, indirect, and molecular (PCR) diagnostic methods, as well as etiological treatment based on benznidazole and nifurtimox.

Chagas disease remains a significant public health challenge due to its high prevalence in vulnerable regions and its socioeconomic impact. The article concludes that strengthening epidemiological surveillance and ensuring access to timely diagnosis and treatment are essential to prevent fatal complications and improve the quality of life of those affected.

The objective of this research is to collect and analyze up-to-date information on Chagas disease, with a special focus on its epidemiology in Mexico and Latin America, the challenges of diagnosis and the management of its clinical complications.

Keywords: Chagas disease, *Trypanosoma cruzi*, public health.

INTRODUCTION

Chagas disease (CD), also called American trypanosomiasis, is a tropical disease caused by the flagellated protozoan *Trypanosoma cruzi* [1].

Chagas disease is the third most common parasitic disease worldwide, after malaria and schistosomiasis; it is also considered the most important parasitic disease in the Western world, with an estimated disease burden (disability-adjusted life years) 7.5 times greater than that of malaria [2].

It affects between 6 and 8 million people worldwide and causes approximately 50,000 deaths per year. An additional 65 to 100 million people live in areas at risk of infection worldwide.

Although more than a century has passed since its discovery, CD remains one of the main public health problems in most Latin American countries. In recent decades, celiac disease has also become a concern in non-endemic areas such as Canada, the United States, Europe, Australia, and Japan due to the constant migration of individuals from endemic regions (3).

As mentioned previously, celiac disease is a global problem that affects people daily in both endemic and non-endemic countries, primarily due to the high rate of migration to these territories. Therefore, it presents a challenge for global public health institutions to develop and implement timely diagnostic measures, since it not only affects individuals but also impacts socioeconomic levels, where the ability to generate income for subsistence becomes a greater challenge.

Therefore, according to the guidelines established by the Ministry of Health, it is necessary to make an accurate diagnosis, confirming the presence of *T. cruzi* through direct or indirect parasitological methods. Furthermore, patients should receive pre- and post-diagnosis counseling regarding the disease and their right to care [1].

The objective of this research is to gather information on Chagas disease, focusing on its epidemiology in Mexico and Latin America, the challenges and limitations involved in diagnosis, the disease's progression to Chagas cardiomyopathy, and its treatment.

Using the available literature, this study aims to emphasize the epidemiology of Chagas disease to highlight its relevance in the Potosí region, given its association with a poor quality of life for those affected.

BACKGROUND

Chagas disease (CD) was named after its discoverer, Carlos Ribeiro Justiniano Chagas, who was born on a coffee plantation in Oliveira, Minas Gerais state, Brazil, on July 9, 1878. Chagas graduated with a medical degree in 1903 and was invited by Oswaldo Cruz to work as a physician at the Brazilian Ministry of Public Health and Hygiene, where he first implemented indoor vector control against malaria.

On February 14, 1909, Chagas examined a patient who would become the first case of CD described in the literature: a two-year-old girl, Berenice, who presented

with high fever, hepatosplenomegaly, facial edema, and the presence of the parasite in her blood. Berenice remained asymptomatic throughout her life and died at age 73 from other causes. She was included in several clinical studies of CD from age 55 to 71.

The history of Chagas disease can be divided into three important phases:

- **1909 to 1934** - Identification and recognition of the disease.
- **1935 to 1960** - Clinical characterization and definition of its endemic nature.
- **1961 to the present** - Challenges for the implementation of public health policies for the control of Chagas disease.

EPIDEMIOLOGY

Chagas disease is included in the list of neglected tropical diseases published annually by the World Health Organization (WHO) due to its prevalence in low socioeconomic populations living in tropical and subtropical regions with poor sanitation and in close contact with infectious vectors.

Most people at high risk of infection often face multiple barriers to proper evaluation, diagnosis, and treatment due to limited access to healthcare. According to estimates from the WHO's 2010 epidemiological update on Chagas disease in Latin America, more than five million people are infected with *T. cruzi* in 21 Latin American countries. Argentina, Brazil, and Mexico had the highest prevalence, followed by Bolivia and Colombia.

It is estimated that between 20% and 25% of people infected with Chagas disease have Chagas cardiomyopathy, representing almost two million people [4].

In a systematic review with meta-analysis conducted in Mexico by Arnal A *et al.,* an analysis of epidemiological survey data from 2006 to 2017, found an estimated national seroprevalence of *T. cruzi* of 3.38%, with more than 4.06 million cases in Mexico [1]. The prevalence of *T. cruzi* infection in the adult population was 6.5% in San Luis Potosí [5].

In San Luis Potosí, according to data from the State Health Secretariat, a total of 261 infections were reported between 2003 and 2012, with Health Jurisdictions V and VI (corresponding to the Huasteca region) reporting the majority of cases [6]. Of 734 participants in the town of Zacatipan, Tamazunchale, SLP, the seroprevalence was 6.3% (n=46) [7].

ETIOLOGICAL AGENT

Also known as American trypanosomiasis, Chagas disease is caused by the protozoan parasite *T. cruzi*, an intracellular hemoflagellate parasite belonging to the order *Kinetoplastida*, family *Trypanosomatidae*. It has the ability to infect any cell, primarily macrophages, fibroblasts, and epithelial cells.

During its life cycle, the parasite develops through three main forms: **amastigotes** (the proliferative form found within the host cells of vertebrates), **epimastigotes** (the proliferative form found in the intestines of invertebrate hosts), and **trypomastigotes** (the infectious form present in the host's serum).

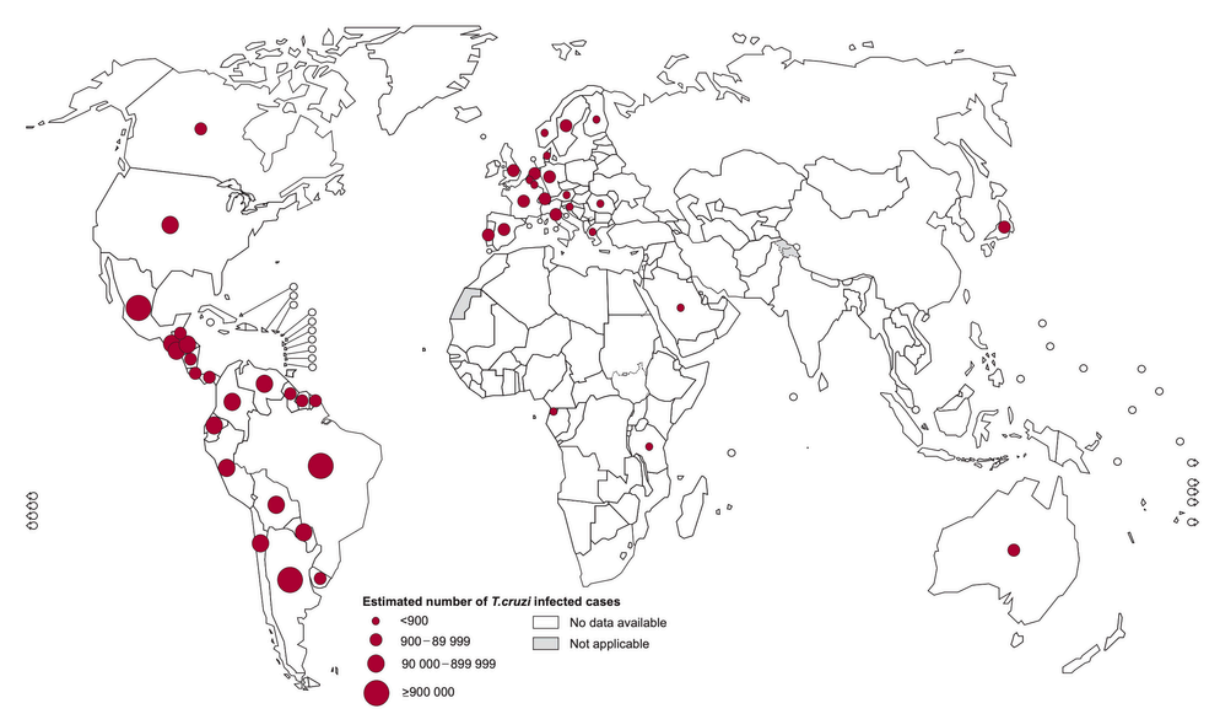


Figure 1. Global distribution of Chagas disease cases (2018). Taken from: World Health Organization. Global distribution of cases of Chagas disease, based on official estimates, 2018 [Internet]. Geneva: World Health Organization; 2018. Available from: https://cdn.who.int/media/docs/default-source/ntds/chagas-disease/chagas-2018-cases.pdf?sfvrsn=f4e94b3b_2.



Figure 2. *Trypanosoma cruzi* vector. Image from: https://www.cdc.gov/dpdx/trypanosomiasisamerican/index.html

Chagas disease is a vector-borne illness, with the parasite transmitted by hematophagous bugs, also known as kissing bugs (Figure 2) [3].

Trypomastigotes are found in feces near the bite wound or in intact mucosal tissues such as the conjunctiva. Within the host, trypomastigotes invade cells near the inoculation site, where they differentiate into intracellular amastigotes. These amastigotes multiply and differentiate again into trypomastigotes that are unable to replicate. Finally, these forms are released into the bloodstream and can infect cells in various tissues, transforming into intracellular amastigotes (Figure 3) [4].

PATHOGENESIS

The infection has two successive phases. The **acute phase** is characterized by high parasitemia, generally asymptomatic or oligosymptomatic, with fever, anorexia, and tachycardia. These manifestations resolve spontaneously in 90% of cases, and possibly between 60% and 70% of infected individuals will never develop signs or symptoms related to Chagas disease, which characterize the indeterminate form.

The remaining patients (30-40%) may progress to the **chronic phase** with neurological, cardiac, digestive (megacolon or megaesophagus), or cardiodigestive clinical symptoms. Chronic Chagas cardiomyopathy (CCC) is the most severe manifestation of the disease [3].

The complex host-parasite relationship that characterizes Chagas disease determines tissue damage and, therefore, myocardial involvement.

Local changes include the development of interstitial edema, lymphocytic infiltration, and reactive hyperplasia of the lymph nodes. The main sites of tissue involvement are muscle and ganglion cells, including the myocardium [4]. Infection of cardiac muscle cells, macrophages, neurons, and nervous support tissue (glial cells) can produce the most prominent lesions of this disease. Following transmission of the parasite by the vector, the incubation period is 1 to 2 weeks. After this period, an acute phase occurs, followed by a chronic phase [2].

From the time of infection by the parasite through inoculation by the triatomine bug, three phases in the development of the pathology are considered, according to authors and international organizations. Based on detections in patients under close monitoring, these phases are divided as follows:

- **Acute Phase**

Most cases in the acute phase are asymptomatic. At this stage, the invasive trypomastigote form can be detected in peripheral blood (parasitemia peaks 30 days after infection). Signs and symptoms of the vector-borne acute form appear after an incubation period of 7 to 30 days.

Occasionally, a specific edematous skin lesion (called a chagoma) may be observed at the entry site, in areas of thin skin. In 1934, Romaña and Mazza described their eponymous pathognomonic sign of unilateral, non-pitting eyelid edema with conjunctivitis and generalized facial edema (Figure 4).

The edema, secondary to lymphatic vessel obstruction, is the primary lesion, where the replicative form of the parasite, the amastigote, multiplies and progresses to invade the reticuloendothelial system. It may also present with hepatosplenomegaly, lymphadenopathy, and chagoma (a local inflammatory process) [2]. General and nonspecific symptoms of the acute phase include tachycardia, anorexia, malaise, vomiting, myalgia, and headache [8].

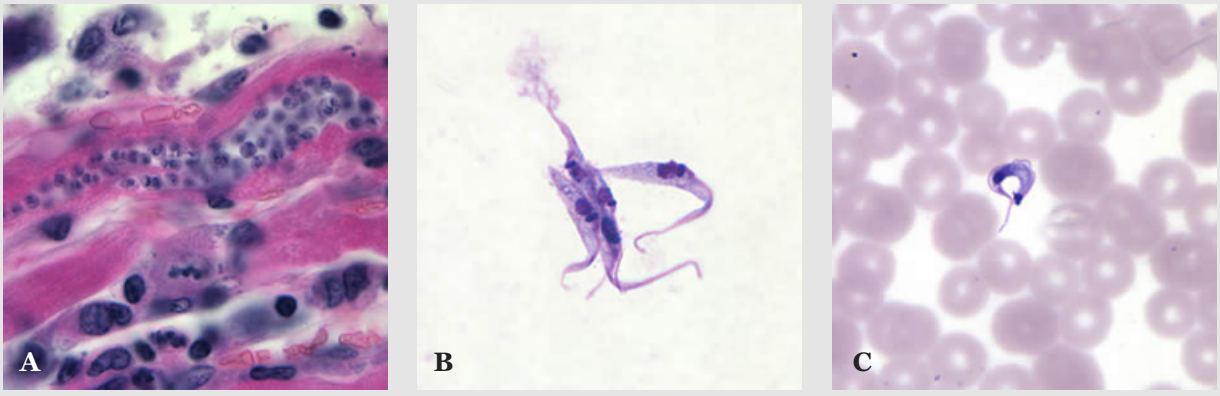


Figure 3. Main forms of *T. cruzi*. A) Amastigotes in cardiac tissue; hematoxylin and eosin (H&E) stain. B) Epimastigotes in culture. C) Trypomastigote in blood smear; Giemsa stain. Images from: https://www.cdc.gov/dpdx/trypanosomiasisamerican/index.html



Figure 4. Romaña's sign. Taken from: Beucler N, Torrico F, Hibbert D. A tribute to Cecilio Romaña: Romaña's sign in Chagas disease. PLoS Negl Trop Dis. 2020 Nov 12;14(11):e0008836. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7660534/

- **Indeterminate Phase**

After 4 to 8 weeks of the acute phase, the cell-mediated immune response controls replication, symptoms subside, and the disease enters the indeterminate phase. In this phase, there are no symptoms and no electrocardiographic abnormalities. 70-80% of the infected population remains in this phase for the rest of their lives [2].

- **Chronic Phase**

If left untreated, the acute phase is followed in 70% of cases by an indeterminate phase (asymptomatic infection) that can last a lifetime. The remaining 30% progress, within 10 to 30 years, to a chronic symptomatic form that affects the heart (20-30% of infections), the gastrointestinal tract (15-20%), and, more rarely, the peripheral nervous system (sensory polyneuropathy, less than 5%) [8].

COMPLICATIONS

- **Chagasic Cardiomyopathy**

Cardiac involvement is the most severe manifestation of chronic Chagas disease. It appears years or decades after the initial infection. It is a progressive disease characterized by a continuous inflammatory immune response that leads to myocardial damage and fibrosis [2].

Unlike other causes, Chagasic cardiomyopathy is characterized by its fibrosing nature, with alterations that begin in the posterobasal, posteroinferior, or apical region of the left ventricle, where a ventricular aneurysm typically appears. It affects the sinoatrial node and the atrioventricular node and can progress to a global condition. It has a high thrombogenic and arrhythmogenic predisposition, causing atrial fibrillation, extreme bradycardia, and ventricular tachycardia, which is the leading cause of death in this group of patients [9].

When infection and lysis of myocardial cells occur, an immune response against *T. cruzi* is triggered through the activation of phagocytic and cytotoxic cells, as well as the production of Th1-type cytokines. This response protects the host during the acute phase; however, due to chronicity, myocardial tissue damage is associated with an exacerbated inflammatory response, primarily mediated by T lymphocytes. Myocyte hypertrophy with abundant fibrosis occurs, leading to ventricular remodeling with bilateral ventricular dilation.

Thinning of the ventricular walls is common, as are apical aneurysms, aneurysms of the posterior wall of the left ventricle, and the development of mural thrombi. The combination of right bundle branch block and left anterior fascicular block is one of the earliest signs and is present in 25% of patients. Periganglionic inflammation of neurons of the parasympathetic nervous system occurs, leading to autonomic dysfunction. Chagas disease can present with various clinical manifestations in the heart, ranging from asymptomatic forms to severe cardiac disease, such as heart failure (the most frequent clinical presentation) and sudden death [2].

- **Chagasic colonopathy**

It presents as megacolon and, in later stages, as enlargement of the organ (megadolicocolon). Clinically, progressive constipation is characteristic, with periods of abdominal distension and flatulence. Diagnosis is based on plain abdominal radiography or a barium enema with contrast medium. Complications are generally due to intestinal obstruction, and treatment is surgical [9].

DIAGNOSIS

Diagnosing a patient with Chagas disease is a complex process that encompasses epidemiological criteria based on the prevalence and incidence of confirmed cases of the disease in the areas of residence of those seeking medical services. Clinical criteria, including the patient's symptoms, form the basis for suspecting the possible condition. Finally, to confirm the case, laboratory tests are used, resulting in a positive or negative diagnosis.

Laboratory diagnosis of *T. cruzi* infection [9] can be performed by:

- **Direct methods**, which verify the presence of the parasite in the sample.
  - Microscopic observation of fresh peripheral blood.
  - Thick blood smear.
  - Microstrout concentration method.

- **Molecular methods**, which verify the presence of the parasite's genetic material in the sample.
  - Qualitative PCR is the confirmatory test in immunocompromised individuals and children under 9 months of age.
  - Quantitative PCR allows for the measurement of parasite load and is especially useful in immunocompromised patients and organ donors. It also allows for post-treatment monitoring.

- **Indirect methods** detect the presence of specific antibodies against the parasite in the sample.
  - Indirect hemagglutination.
  - Enzyme-linked immunosorbent assay (ELISA).
  - Indirect immunofluorescence.
  - Western blot (Immunoelectrotransfer).

TREATMENT

Etiological treatment is divided into two established objectives [9] (Table 1).

- **Primary objective:** to eliminate the parasite and contribute to reducing the likelihood of developing clinical manifestations of the disease and its complications.
- **Secondary objective:** to contribute to interrupting the chain of transmission of *T. cruzi*.

If treatment has been interrupted for a period of less than 14 days, it will be continued for the same number of days until the 60 days of medication administration are completed. If the interruption is longer than 14 days, it will be necessary to restart treatment [9].

CONCLUSION

In conclusion, Chagas disease remains a significant public health challenge worldwide, especially in endemic regions of Latin America, but also in non-endemic areas due to migration. American trypanosomiasis, caused by *T. cruzi*, affects millions of people, with a considerably high disease burden that impacts not only individuals but also the socioeconomic sphere.

The disease, which can remain asymptomatic in most infected individuals, progresses in a significant percentage of patients to chronic stages with severe manifestations, such as Chagas cardiomyopathy, which is the leading cause of mortality in these cases.

This underscores the importance of timely diagnosis and appropriate treatment, which aims not only to eliminate the parasite but also to prevent severe complications and reduce transmission.

Despite advances in its understanding and control, Chagas disease remains a neglected disease, with significant barriers to its proper management, especially in vulnerable populations. The need for effective and accessible health policies, as well as the implementation of epidemiological surveillance, diagnosis and treatment programs, are essential to reduce the burden of this disease and improve the quality of life of those affected.

Funding

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Conflict of interest

The author declares no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

Table 1. Dosage Schedule.

Population	Benzonidazole	Nifurtimox	Comments
Pediatrics	10 mg/kg/day, orally, in two or three divided doses for 60 days. Do not exceed the maximum daily dose of 300 mg.		When the daily dose exceeds 300 mg, it is recommended to extend the treatment period until the total calculated dose for 60 days is reached.
Adults	5-10 mg/kg/day in two divided doses after meals for 60 days, not exceeding 300 mg as the maximum daily dose.	10 mg/kg/day in patients weighing less than 40 kg and 8 mg/kg/day in patients weighing more than 40 kg. Administer in three divided doses after meals for 60 days, not exceeding the maximum dose of 700 mg.	

Original design, with data obtained from Gob.mx. (2019). PROCEDURES MANUAL FOR CHAGAS DISEASE IN MEXICO.

REFERENCES

1. Amell MAA, R D. La enfermedad de Chagas y sus repercusiones en la salud de los pacientes en Latinoamérica. 2021.
2. Suárez C, Nolder D, García-Mingo A, Moore DAJ, Chiodini PL. Diagnosis and clinical management of Chagas disease: an increasing challenge in non-endemic areas. Res Rep Trop Med. 2022;13:25-40. doi:10.2147/RRTM.S278135.
3. Hines Chaves KD, Rodríguez R. Enfermedad de Chagas: afección cardiaca. 2019.
4. Secretaría de Salud. Manual de procedimientos para la enfermedad de Chagas en México. Ciudad de México: Gobierno de México; 2019.
5. Hines Chaves KD, ZV. Enfermedad de Chagas: afección cardiaca. Rev Med Sinerg. 2019. (Faltan volumen, número y páginas).
6. Medina Garza H, CC. Análisis espacial de la enfermedad de Chagas. 2014.
7. Ramsey JM, Alvear-Pérez L. Enfermedad de Chagas: omisión u olvido en la salud pública de México. 2022.
8. Lidani KCF, Andrade FA, Bavia L, Damasceno FS, Beltrame MH, Messias-Reason IJ, et al. Chagas disease: from discovery to a worldwide health problem. Front Public Health. 2019;7:166. doi:10.3389/fpubh.2019.00166.
9. Aldana Cruz O, OA. Seroprevalencia de la enfermedad. 2009.
10. Pino-Marín A, Medina-Rincón G, Buitrago-Corredor C, et al. Chagas cardiomyopathy: from Romaña sign to heart failure and sudden cardiac death. Pathogens. 2021;10(11):1388. doi:10.3390/pathogens10111388.

The True Mechanism of Calcium Treatment for Hyperkalemia: Beyond Cell Membrane Stabilization

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ABSTRACT

Hyperkalemia is a potentially lethal metabolic disorder characterized by an increase in serum potassium above 5.0 mEq/L (or 5.0 mmol/L). Severe hyperkalemia can trigger fatal arrhythmias by altering cardiac electrophysiology, specifically conduction and repolarization, manifesting as electrocardiographic changes such as QRS widening and a sinusoidal wave pattern.

In Mexico, its incidence and prevalence are closely linked to highly prevalent chronic diseases such as chronic kidney disease (CKD) and diabetes mellitus, as these conditions predispose to potassium accumulation in the blood due to decreased renal excretion and the use of medications that interfere with potassium metabolism.

While managing this condition is a common challenge in critically ill patients, calcium gluconate administration has traditionally been a key intervention in the acute management of hyperkalemia. However, recent studies suggest that, contrary to the prevailing view that its mechanism of action lies in "membrane stabilization," its primary effect is to restore electrical conduction through the activation of L-type calcium channels and ephaptic coupling.

The aim of this article is to provide the reader with context and disseminate these findings in order to highlight their importance in making informed clinical decisions in this clinical scenario.

Keywords: hyperkalemia, calcium, membrane stabilization.

INTRODUCTION

Potassium in its ionic form is a fundamental element in both excitable and non-excitable cells, as it regulates and maintains the resting membrane potential, cellular homeostasis, and other metabolic functions. Approximately 2% of the body's total potassium is found in the extracellular fluid, while 98% of exchangeable potassium is located in the intracellular compartment, establishing the resting plasma membrane potential of cells.

Hyperkalemia is the elevated concentration of serum potassium, typically above 5 mmol/L. If this alteration persists or worsens, it significantly affects cardiac electrical conduction, generating a risk of serious arrhythmias that could lead to death [1] (Figure 1). This condition is closely associated with pathologies of epidemiological relevance in Mexico, such as diabetes mellitus, systemic hypertension (and its management), and chronic kidney disease (CKD), making it essential to understand it.

The main clinical manifestations of hyperkalemia include neuromuscular symptoms such as paresthesia and fasciculations in the extremities, and ascending paralysis, which can eventually progress to flaccid quadriplegia. The trunk, head, and respiratory muscles usually remain unaffected, so respiratory failure is uncommon [2].

In addition, cardiac conduction abnormalities, detailed later, are observed.

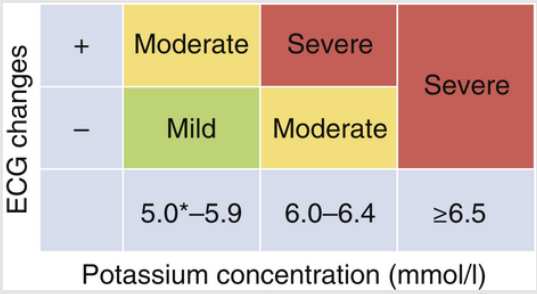


Figure 1. Classification of hyperkalemia. Consensus from the Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. 2020. Adapted from: Clase CM, Carrero JJ, Ellison DH, Grams ME, Hemmelgarn BR, Jardine MJ, Kovesdy CP, Kline GA, Lindner G, Obrador GT, Palmer BF, Cheung M, Wheeler DC, Winkelmayer WC, Pecoits-Filho R; Conference Participants. Potassium homeostasis and management of dyskalemia in kidney diseases: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidney Int. 2020 Jan;97(1):42-61. doi: 10.1016/j.kint.2019.09.018. *5 or upper limit of normal.

HYPERKALEMIA AND CARDIAC ACTION POTENTIAL

The cardiac action potential (AP) differs from others (neuronal, skeletal muscle) due to the presence of a

plateau phase during repolarization and a longer overall duration, resulting from a precise interaction between ions, primarily sodium (Na^+), potassium (K^+), and calcium (Ca^{2+}) (Figure 2).

In normal cardiac muscle, the resting membrane potential (RMP) is close to -85 mV, while the depolarization threshold (DT) is close to -65 mV. Following nerve stimulation and during the so-called phase 0, the rapid influx of Na^+ promotes depolarization of the cell membrane. Repolarization then begins, divided into four phases. In phase 1, K^+ efflux begins, continuing throughout phase 2 (also called the plateau phase), during which L-type Ca^{2+} channels are activated, allowing the entry of this ion.

Its interaction with RyR receptors in the sarcoplasmic reticulum ultimately triggers the coupling of myosin and actin in muscle contraction. During phase 3, the influx of sodium and calcium ceases, and repolarization, driven by the late reentry of K^+, predominates. During phase 4, or the resting phase, the muscle returns to its resting state through the action of the Na^+/K^+ ATPase and the Na^+/Ca^{2+} type 1 exchanger (NCX1) [3, 4, 5].

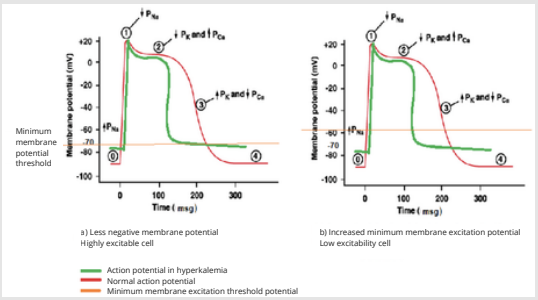


Figure 2. Effects of hyperkalemia on the cardiac action potential. Left: Initially, the cell becomes hyperexcitable as the resting membrane potential becomes more positive due to the increase in extracellular potassium, while repolarization is achieved in a shorter time. Right: As hyperkalemia becomes established, the depolarization threshold becomes less negative; this, combined with the shortening of phase 3 of repolarization, makes it more difficult for a stimulus to achieve sufficient magnitude to induce depolarization. Adapted from: Clinical Fundamentals. Potassium [Internet]. [cited January 31, 2025]. Available from: https://fundamentosclinicos.com/content/potasio

The characteristics of the cardiac action potential vary along the myocardial wall, from the endocardium, through the mid-myocardium, to the epicardium. Epicardial cells exhibit a prominent phase 1 and a shorter action potential [5].

In hyperkalemia, there is increased permeability to K^+, which makes the action potential less negative, bringing it closer to the diastolic threshold (DT) and initially facilitating conduction. However, if this persists, the DT also becomes less negative, requiring stronger stimuli to open Na+ channels in phase 0. This progressively hinders the excitability of the cardiac conduction system (Figure 2), which in turn results in arrhythmias [6].

On the ECG, this manifests as peaked T waves, flattened P waves, prolonged PR interval, widened QRS complex, and a sinusoidal wave pattern [7] (Table 1).

Approximate Serum K^+ Concentration	Illustrative EKG	EKG Changes
4.0		None
6.0		Peaked T-wave
8.0		P-wave flattening Prolonged PR Prolonged QRS
>9.0		Sine wave/asystole

Table 1. Effects of hyperkalemia on the electrocardiogram (ECG). Approximate values. Adapted from: Gupta AA, Self M, Mueller M, Wardi G, Tainter C. Dispelling myths and misconceptions about the treatment of acute hyperkalemia. Am J Emerg Med. 2022;52:85-91. Available from: https://doi.org/10.1016/j.ajem.2021.11.030.

BEYOND MEMBRANE STABILIZATION

Calcium administration in the form of calcium gluconate is one of the main measures for controlling electrophysiological alterations in cardiac muscle. However, when its mechanism of action was questioned, the answer was limited to a deduction: considering that calcium gluconate does not directly reduce serum potassium levels, its action must be related to the cell membrane, specifically the restoration of the resting membrane potential (RMP) (i.e., membrane stabilization) [7,8]. Until recently, the details of this mechanism eluded general knowledge.

Piktel *et al.* [9] suggest that the restoration of conduction velocity after calcium administration under hyperkalemic conditions is achieved without modifications to the RMP and propose some theories about its mechanism of action:

1. ***L-type calcium channels:*** The activation of these voltage-gated channels during the plateau phase and the consequent influx of calcium into the cell, facilitated by the increase in extracellular calcium levels, appears to be achieved even when the resting potential is elevated.
2. ***Ephaptic coupling:*** This physiological phenomenon, described primarily in nervous tissue (Figure 3), occurs when voltage changes during an axon's action potential induce a new action potential in a neighboring axon via local extracellular electric fields. Studies suggest that this mechanism plays an important role in facilitating and propagating the electrical impulse in cardiac tissue during rapid heart rhythms, even in tissues with poorly coupled gap junctions (poor connexin expression), acting as a "lifeline" for conduction blocks [10, 11, 12]. Calcium can reduce the space between intercellular gap junctions,

optimizing conduction and compensating for the decrease in sodium channel function, thus contributing to the restoration of cardiac conduction.

These findings challenge the conventional view that calcium stabilizes cell membranes by restoring the resting potential. Instead, its main effect lies in maintaining the efficient propagation of electrical impulses.

CLINICAL RELEVANCE

Understanding these mechanisms allows the physician in training to understand the reasoning behind the intravenous administration of calcium when electrocardiographic alterations consistent with hyperkalemia are observed, and therefore will allow them to make informed and accurate decisions in their future practice.

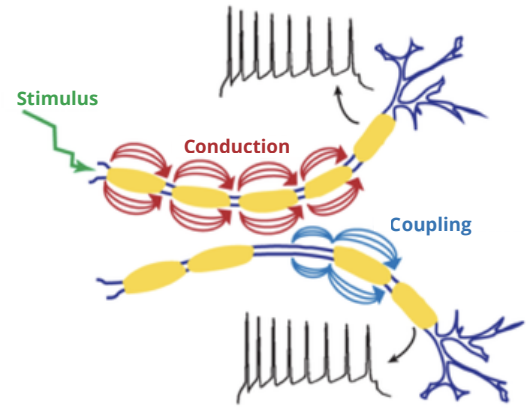


Figure 3. Ephaptic coupling (illustrative). This occurs when voltage changes during the action potential of an excitable membrane induce the firing of a new action potential in a neighboring excitable membrane. Calcium acts by reducing the physical space between membranes, facilitating this alternative mechanism of impulse propagation. *Translated from Spanish to English.* Taken from: Treviño-Frenk I. Transient symptoms in multiple sclerosis. Rev Mex Neurociencia [Internet]. 2015 [cited 2025 Jan 6];16(3):32-33. Available from: https://previous.revmexneurociencia.com/wp-content/uploads/2016/03/RevMexNeuroci-No-3-May-Jun-2015-26-38R.pdf

CONCLUSION

Intravenous calcium improves electrical conduction in severe hyperkalemia through novel mechanisms such as L-type channel activation and ephaptic coupling. This knowledge updates clinical practice by strengthening the theoretical basis for physicians' actions in managing and preventing the cardiac complications of hyperkalemia. The main limitations of the article are related to the nature of the experimental (animal) model, which could call into question the extrapolation of the results to human conditions, and to the possible interaction of calcium with other common therapies for the conditions with which it is associated, such as insulin, ion exchange resins, and others.

Funding

This work received no external funding.

Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

REFERENCES

1. Clase, CM, Carrero JJ, Ellison DH, Grams ME, Hemmelgarn BR, Jardine MJ, Kovesdy CP, Kline GA, Lindner G, Obrador GT, Palmer BF, Cheung M, Wheeler DC, Winkelmayer WC, Pecoits-Filho R; Conference Participants. Potassium homeostasis and management of dyskalemia in kidney diseases: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidnet Int. 2020 Jan;97(1):42-61. doi:10.1016j.kint.2019.09.018.
2. Palmer BF, Clegg DJ. Diagnosis and treatment of hyperkalemia. Cleve Clin J Med. 2017 Dec;84(12):934-942. doi: 10.3949/ccjm.84a.17056. PMID: 29244647.
3. Grant AO. Cardiac ion channels. Circ Arrhythm Electrophysiol. 2009 Apr;2(2):185-194. doi:10.1161/CIRCEP.108.789081.
4. Aziz Q, Li Y, Tinker A. Potassium channels in the sinoatrial node and their role in heart rate control. Channels (Austin). 2018;12(1):356-366. doi:10.1080/19336950.2018.1532255.
5. Kléber AG, Rudy Y. Basic mechanisms of cardiac impulse propagation and associated arrhythmias. Physiol Rev. 2004 Apr;84:431-88. doi: 10.1152/physrev.00025.2003
6. Fundamentos Clínicos. Potasio [Internet]. [citado 31 de enero de 2025]. Disponible en: https://fundamentosclinicos.com/content/potasio
7. Gupta AA, Self M, Mueller M, Wardi G, Tainter C. Dispelling myths and misconceptions about the treatment of acute hyperkalemia. Am J Emerg Med. 2022 Feb;52:85-91. doi: 10.1016/j.ajem.2021.11.030. Epub 2021 Nov 27. PMID: 34890894.
8. De Sequera P, Alcázar Arroyo R, Albalate Ramón M. Trastornos del potasio: Hipopotasemia e hiperpotasemia. Nefrología al Día [Internet]. Disponible en: https://www.nefrologiaaldia.org/es-articulo-trastornos-del-potasio-hipopotasemia-hiperpotasemia-383

9. Piktel JS, et al. Beneficial Effect of Calcium Treatment for Hyperkalemia Is Not Due to “Membrane Stabilization.” Critical Care Medicine. 2024;52(10):1499-1507. DOI:10.1097/CCM.0000000000006376.
10. Weinberg, SH. Ephaptic coupling rescues conduction failure in weakly coupled cardiac tissue with voltage-gated gap junctions. Chaos. 2017 Sep;27 (9):093908. doi: 10.1063/1.4999602
11. Lin J, Keener JP. Ephaptic Coupling in Cardiac Myocytes. IEEE Trans Biomed Eng. 2013 Feb;60 (2):576-82. doi:10.1109/TBME.2012.2226720
12. Wei N, Mori Y, Tolkacheva, EG. The dual effect of ephaptic coupling on cardiac conduction with heterogeneous expression of connexin 43. Journal of Theoretical Biology. 2016 Mar 8;397:103-14. doi: 10.1016/j.jtbi.2016.02.029

Male Contraceptive Methods in Development

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ABSTRACT

The article highlights that, despite approximately 50% of pregnancies worldwide being unplanned, modern contraceptive options for men are almost exclusively limited to condoms and vasectomy. The document analyzes the development of hormonal methods, such as dimethandrolone undecanoate (DMAU) and 11β-MNTDC, which aim to suppress sperm production by inhibiting gonadotropic hormones. It also describes promising non-hormonal alternatives, including reversible polymeric barriers such as VasalGel and RISUG, and the disruption of retinoic acid synthesis through enzyme inhibition.

The development of new male contraceptives represents a critical advance for public health and equity in reproductive responsibility. Although many of these methods still require further research on their safety and reversibility, their future implementation could significantly transform family planning practices globally.

The aim of this work is to review recent advances in the development of male contraceptive methods, exploring both hormonal and non-hormonal options, in order to encourage greater male participation in family planning and reduce the rate of unwanted pregnancies.

Keywords: male contraceptives, family planning, reproductive health.

INTRODUCTION

The oldest method of contraception is the male condom, which remains one of the most widely used methods today. There are reports that early versions were used in ancient Egypt; however, the first documented reports on condoms date back to 1564, published by Gabriello Falloppio, in which they were described as a method to prevent syphilis infection.

Currently, approximately 50% of all pregnancies are unplanned, and these figures are even higher among adolescents in the United States. Of the half of modern contraceptives available, only two are for men: condoms or vasectomy.

Hormonal methods can successfully block sperm production, thus interfering with spermatogenesis. Contraceptive options for men are based on various hormonal regimens that achieved 94% effectiveness in clinical studies, but have been abandoned due to undesirable side effects such as acne, behavioral changes, etc.

The development of contraceptive methods has had a major impact on fertility rates, women's health, the role of women in society, and the sexual practices of adults and adolescents.

The failure rate in these methods ranges from <1% to >20%, depending on the method.

The aspects that still generate debate regarding the mechanisms of action these methods should have are the site and time at which they should act.

In this respect, there are three opinions:

1.- That their result is azoospermia.

- Advantages: Their effect can be measured quantitatively, and their result in infertility is easily obtained through testing.
- Disadvantages: They are slow to establish and reverse, as they target meiotic divisions.

2.- That they act against mature sperm.

- Advantages: They are quick to establish and reverse; there is no testicular change.
- Disadvantages: These methods are effective against all viable sperm present in ejaculation.

3.- That they produce morphologically abnormal sperm.

- Advantages: They are quick to establish.
- Disadvantages: Some viable sperm may remain for fertilization.

HORMONAL METHODS

Hormonal contraceptives for men involve administering exogenous hormones to prevent spermatogenesis. These hormones affect the hypothalamic-pituitary axis, inducing negative feedback from testosterone on this axis, ultimately suppressing the secretion of FSH and LH.

Currently, various types of male contraception are being researched, with oral formulations being one group of options.

Dimethandrolone undecanoate (known as DMAU) is a compound that shows great promise. It is administered to patients in ester form and is then metabolized in the body to DMA (dimethandrolone). After 28 days of oral administration, a decrease was observed in plasma levels of luteinizing hormone (LH), responsible for the proper functioning of the interstitial cells of the testes where testosterone is produced; follicle-stimulating hormone (FSH), responsible for stimulating sperm production and increasing the production of androgen-binding protein (ABP); and testosterone levels, which affected male fertility.

After seven days of taking DMAU, a significant decrease was observed in the levels of gonadotropic hormones and testosterone (median <24 ng/dL) produced in the body. DMAU binds to progesterone and androgen receptors located in the pituitary gland and hypothalamus, thereby inhibiting the secretion of pituitary hormones that affect testicular hormonal activity. Specifically, the hypothalamus stops secreting GnRH, and the pituitary gland stops secreting LH and FSH, through negative feedback.

11β-Methyl-19-nortestosterone-17β-dodecylcarbonate (11β-MNTDC) is another substance tested as a male oral contraceptive. It is a prodrug in ester form that is converted in vivo to the active substance: 11β-methyl-19-nortestosterone. Like DMA, it inhibits androgen secretion by binding to androgen and progesterone receptors. Taking this substance with food has been found to significantly increase its serum concentration. Doses of 200, 400, and 800 mg effectively reduced sex hormone levels.

Segesterone acetate is a novel progestin (Nestorone) that has been formulated as a transdermal gel for daily use in combination with a topical testosterone gel in male contraceptives. A study has shown that over 80% of men who received 8 mg per day of segesterone acetate with testosterone, and who applied Nestorona gel daily with testosterone gel, experienced a reduction in sperm concentration to less than one million per milliliter.

NON-HORMONAL METHODS

VasalGel, a high molecular weight (360 kDa) styrene-malic acid (SMA) polymer, is administered intramuscularly. This polymer acts as a barrier that sperm cannot cross and can be removed by dimethyl sulfoxide (DMSO). This preparation has already been tested in rabbits and rhesus monkeys. Studies show that this method is also very effective, but further research is needed to determine its absolute safety.

One of the most promising drugs could be **Reversible Inhibition of Sperm Under Guidance (RISUG)**. This styrene-maleic anhydride copolymer, injected into the vas deferens, lowers the pH level and creates a positive charge, thus preventing the proper transport of male reproductive cells through the female reproductive tract.

Sperm counts have been found to be reduced by disrupting retinoic acid synthesis. This can be achieved by **inhibiting the enzyme aldehyde dehydrogenase-1A2 (ALDH1A2) in human germ cells**, which is a catalyst for the conversion of retinaldehyde to retinoic acid.

CONCLUSIONS AND PERSPECTIVES

With the advent of hormonal birth control pills in 1960, women's control over their own bodies and their decision to have children was revolutionized. However, unintended pregnancies remain common.

Advances in hormonal contraceptives for men are a major area of research today, as they present a challenge for the health sector and the scientific community. The goal is not only to improve contraception but also to eliminate societal negative impacts and, most importantly, to increase men's involvement in family planning.

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Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

REFERENCES

1. Long JE, Lee MS, Blithe DL. Male contraceptive development: Update on novel hormonal and nonhormonal methods. Clin Chem [Internet]. 2019;65(1):153–60. Disponible en: http://dx.doi.org/10.1373/clinchem.2018.295089
2. Walton MJ, Kumar N, Baird DT, Ludlow H, Anderson RA. 7 -methyl-19-nortestosterone (MENT) vs testosterone in combination with etonogestrel implants for spermatogenic suppression in healthy men. J Androl [Internet]. 2007;28(5):679–88. Disponible en: http://dx.doi.org/10.2164/jandrol.107.002683
3. Thirumalai A, Amory JK. Emerging approaches to male contraception. Fertil Steril [Internet]. 2021;115(6):1369–76. Disponible en: http://dx.doi.org/10.1016/j.fertnstert.2021.03.047

4. Balbach M, Rossetti T, Ferreira J, Ghanem L, Ritagliati C, Myers RW, et al. On-demand male contraception via acute inhibition of soluble adenylyl cyclase. Nat Commun [Internet]. 2023;14(1). Disponible en: http://dx.doi.org/10.1038/s41467-023-36119-6
5. Johnston DS, Goldberg E. Preclinical contraceptive development for men and women. Biol Reprod [Internet]. 2020;103(2):147–56. Disponible en: http://dx.doi.org/10.1093/biolre/ioaa076
6. Roth MY, Amory JK. Pharmacologic development of male hormonal contraceptive agents. Clin Pharmacol Ther [Internet]. 2011;89(1):133–6. Disponible en: http://dx.doi.org/10.1038/clpt.2010.103
7. Dominiak Z, Huras H, Kręcisz P, Krzeszowski W, Szymański P, Czarnecka K. Promising results in development of male contraception. Bioorg Med Chem Lett [Internet]. 2021;41(128005):128005. Disponible en: http://dx.doi.org/10.1016/j.bmcl.2021.128005
8. Ding D, Liu J, Dong K, Midic U, Hess RA, Xie H, et al. PNLDC1 is essential for piRNA 3′ end trimming and transposon silencing during spermatogenesis in mice. Nat Commun [Internet]. 2017;8(1). Disponible en: http://dx.doi.org/10.1038/s41467-017-00854-4

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Active Recall: The Secret of High-Achieving Students

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ABSTRACT

The purpose of this article is to introduce the reader to the Active Recall technique as an essential learning strategy for today's medical students, detailing its practical implementation, its benefits for academic performance, and the scientific foundations that support it.

Active Recall is defined as a study method that consists of the active retrieval of previously learned information through the use of quizzes, tests, or flashcards, instead of passive memorization. The article explains that this technique forces the brain to make a retrieval effort, which facilitates the identification of gaps in knowledge and fosters a deep and lasting understanding of complex topics. It also highlights the importance of integrating this methodology with spaced repetition to consolidate long-term memory, optimize study time under the principle of "quality hours, not quantity," and prevent student burnout.

Implementing Active Recall is a fundamental tool for managing the vast amount of information in medical school. By taking an active role in their academic training, students not only improve their long-term retention of concepts, but also develop critical skills for their future clinical practice.

Keywords: active recall, spaced repetition, academic performance.

INTRODUCTION

In today's fast-paced world of education, the desire to achieve outstanding academic performance is a goal shared by students of all ages. However, simply investing time in studying is not enough; the true key to success lies in adopting effective study strategies. In this article, we explore one of our favorite science-backed techniques: active recall [1].

Our aim is to equip students of all levels with the tools they need to significantly improve their academic performance. But why is it so important to approach study methods strategically? The answer lies in the fact that passive memorization is no longer sufficient in an information-driven world.

In an increasingly competitive educational environment, active recall emerges as a fundamental tool that not only optimizes learning but also fosters deep and lasting understanding [2].

ACTIVE RECALL

Active recall is an effective study method that involves recalling previously learned information through quizzes or flashcards [3]. In the context of a medical student, this technique is a fundamental tool since both the quantity and complexity of information can be overwhelming [4].

In the daily life of a medical student, active recall can become a valuable tool, as medicine involves learning a vast amount of detail, from basic sciences like anatomy and physiology to clinical sciences like internal medicine and surgery. Future medical minds need all this information to integrate it effectively when facing a patient. As mentioned earlier, this methodology focuses on details that are not always easy to recall after reading the material. Thus, the goal of active recall for medical students is to ensure that acquired knowledge remains with them over time [5].

Active recall works because it involves the constant repetition of information through questioning, answering, and self-assessment. By answering these questions, your brain is forced to actively retrieve information instead of passively studying [6]. Furthermore, by assessing yourself, you can identify areas of weakness and determine where you need to improve.

Now that we know how active recall works, the next step is to be able to implement it in our daily study routine. The first step is to identify the information you want to learn; this can include everything from definitions and concepts to dosage and handling.

One of the most recommended ways to apply active recall is through the use of flashcards and quizzes. These involve writing down questions and answers, and can include diagrams and images that can be helpful when studying the chosen topic. Finally, repeated active recall helps consolidate information in your long-term memory [4].

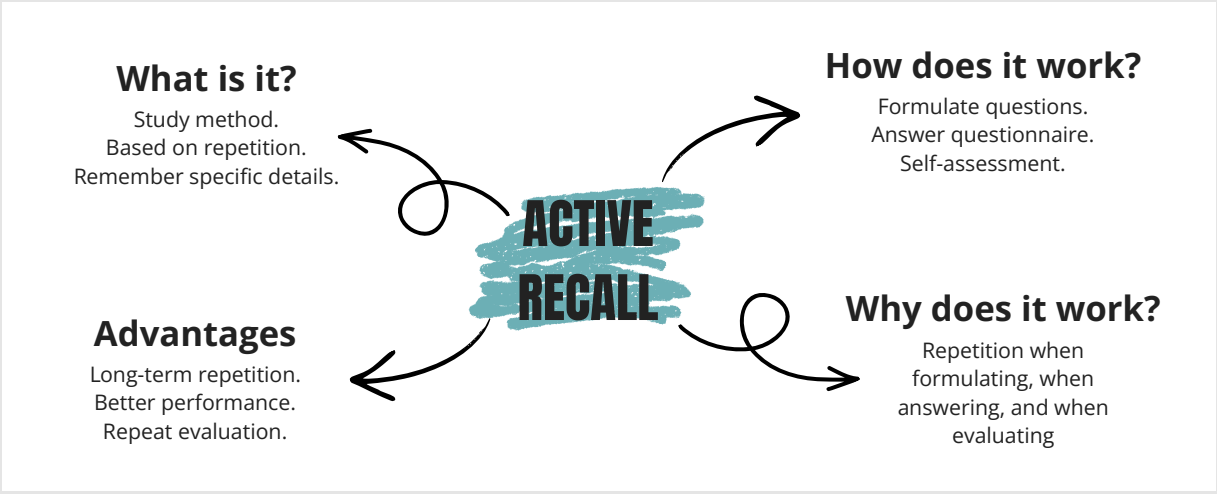


Figure 1. Key points Active Recall. *Image adapted for English translation from the original Spanish version.*

EXAMPLES AND METAPHORS

Upon entering university, students may feel overwhelmed and believe that the path they are on is not right for them. Many students face the major first-year challenge: "learning how to study". Active recall can be a lifeline for many of them. In this section, we will use anatomy as an example, a subject that is often daunting due to its large amount of content. However, what if students could learn effectively without having to spend all day studying? That is, studying quality hours rather than quantity. Active recall could be a very helpful tool.

For example, before anatomy class, students could read or look at relevant illustrations; on the day of class, they could pay attention, noting the most important points; and later that same day, they could review what they learned. In this way, the student will have studied the topic at least three times. Later, on the weekend, they could review the material using flashcards, quizzes, or questionnaires to identify what they remembered, what they forgot, and what they learned [3].

RELEVANCE AND PRACTICAL BENEFITS

Active recall is an efficient, practical, and effective learning technique that offers a wide range of benefits. In addition to reinforcing long-term retention, active recall has proven to be a key tool for fostering a deep understanding of academically challenging concepts and topics [1]. Spaced repetition is a process that demands active and constant student participation, but also, with its characteristic efficient distribution of academic material, plays a fundamental role in preventing student burnout [3].

CONCLUSION

Active recall is an effective study method that involves recalling previously learned information using spaced repetition strategies such as quizzes, tests, or flashcards [3]. Constant repetition promotes active information retrieval rather than passive short-term

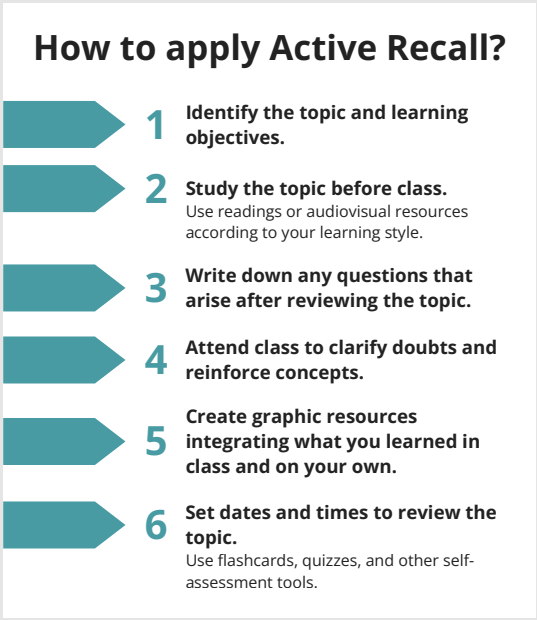


Figure 2. Key points to apply Active Recall. *Image adapted for English translation from the original Spanish version.*

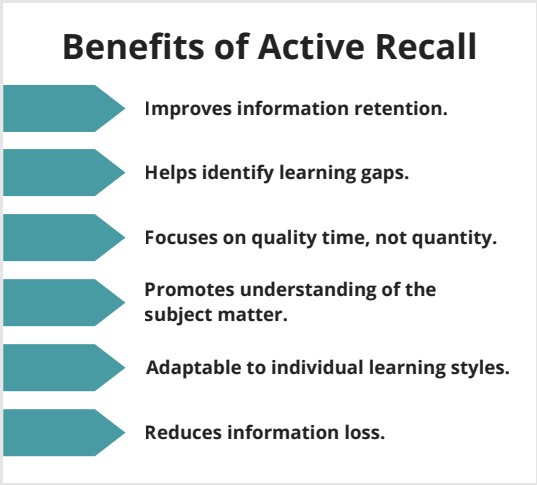


Figure 3. Key points of the benefits of Active Recall. *Image adapted for English translation from the original Spanish version.*

memorization, and the spaced distribution of topics and continuous self-assessment ensure that students take an active role in their academic training and achieve better long-term retention of the reviewed concepts [6].

The main objective of active recall in the context of a medical student is to ensure that previously acquired knowledge remains with them over time by implementing a strategy that not only optimizes learning but also fosters deep and lasting understanding [2].

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This work received no external funding.

Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

This work did not involve the participation of human subjects or animals, nor the collection of primary data; therefore, it did not require approval from a research ethics committee. All data used came from previously published and publicly accessible secondary sources.

REFERENCES

1. Landoll RR, Bennion LD, Maggio LA. Understanding excellence: A qualitative analysis of high-performing learner study strategies. Med Sci Educ [Internet]. 2021 [citado el 19 de octubre de 2023];31(3):1101–8. Disponible en: https://pubmed.ncbi.nlm.nih.gov/34457953
2. Osmosis. Spaced Repetition in learning theory [Internet]. Elsevier; 2016. Disponible en: https://youtu.be/cVf38y07cfk?si=_M6HohJIBwN8anet
3. Nickson C. Learning by spaced repetition [Internet]. Life in the Fast Lane • LITFL. 2019 [citado el 18 de octubre de 2023]. Disponible en: https://litfl.com/learning-by-spaced-repetition/
4. Graffam B. Active learning in medical education: Strategies for beginning implementation. Med Teach [Internet]. 2007;29(1):38–42. Available from: http://dx.doi.org/10.1080/01421590601176398
5. Augustin M. How to learn effectively in medical school: test yourself, learn actively, and repeat in intervals. Yale J Biol Med [Internet]. 2014 [citado el 18 de octubre de 2023];87(2):207–12. Disponible en: https://pubmed.ncbi.nlm.nih.gov/24910566/
6. Owen M. Active recall: The most effective high-yield learning technique [Internet]. Osmosis. [cited 2023 Oct 18]. Available from: https://www.osmosis.org/blog/2022/02/21/active-recall-the-most-effective-highyield-learning-technique



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