



PAINKILLERS, THEIR CHEMICAL COMPOSITION, AND THE MECHANISM OF THEIR EFFECT ON THE HUMAN BODY.

Shukurullayeva Dilnoz
Ulashboyev Dilshodjon
Tashkent medical academy

Article history:	Abstract:
Received: March 11 th 2025 Accepted: April 11 th 2025	This article discusses the chemical composition, classification, and biochemical mechanisms of pain relief of analgesic drugs in the human body. An analysis is provided using examples of paracetamol, novocaine, and aspirin. Additionally, based on the latest scientific research from 2024–2025, information about new analgesics, current issues in the field and their corresponding solutions, as well as global statistics on the usage of analgesics, are presented.

Keywords: Analgesic, analgesic, paracetamol, Novacaine, aspirin, prostaglandin, COX enzyme, Medical Chemistry, suzetrigin.

INTRODUCTION: In medical science, painkillers (analgesics) are among the most important drugs used to reduce or completely eliminate pain. Pain is the body's response to pathological conditions, and controlling it plays a crucial role in improving quality of life. Pain is one of the key indicators of both physiological and pathological states in the human body. In medical practice, various types of painkillers are used to relieve pain. These drugs possess complex chemical structures studied in medicinal chemistry and exert their effects on the body through specific mechanisms.

MAIN PART: The scientifically based definition of pain:
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The International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage." The development of pain involves nociceptors (pain receptors), the spinal cord, thalamus, and cerebral cortex.

Painkillers (analgesics) are divided into two groups:

1. **Narcotic analgesics** (e.g., morphine, codeine) – suppress pain at the brain level and can lead to addiction.
2. **Non-narcotic analgesics** (e.g., paracetamol, novocaine, aspirin) – act on the peripheral and central nervous systems and do not cause addiction.

Paracetamol ($C_8H_9NO_2$ – **4-hydroxyphenylacetamide**):
Used in medicine as an analgesic and antipyretic. Known in some Western countries as acetaminophen, it is the most widely used non-narcotic central analgesic in the world due to its safety. It is used to treat mild to moderate pain, headaches, muscle pain, rheumatic pain, and fever associated with colds. However, in high doses, it can damage the liver, kidneys, and circulatory system. It is included in the WHO list of essential medicines.

Novocaine ($C_{13}H_{20}N_2O_2$ – **2-ethyl 4-aminobenzoate**):
Novocaine is a local anesthetic with mild analgesic effects and broad therapeutic potential. It inhibits the generation of impulses at sensory nerve endings and blocks the transmission of impulses along nerve fibers, thereby blocking pain and other signals. Its effects follow a sequence: first, a sensation of cold, then heat, followed by loss of pain and pressure sensations. It also relaxes smooth muscle spasms, inhibits the release of the neurotransmitter acetylcholine from presynaptic nerve endings, and exhibits partial ganglion-blocking effects. In large doses, it may disrupt neuromuscular transmission.

Aspirin ($C_9H_8O_4$ – Acetylsalicylic acid):
Used in medicine to treat rheumatism, reduce fever, and relieve pain. In small doses, it has blood-thinning properties and is used as an anticoagulant. Because of this, many elderly individuals take low doses of aspirin daily to prevent heart disease and stroke.



Mechanisms of action:

1. **Opioid analgesics** bind to opioid receptors in the brain and spinal cord, blocking the transmission of pain signals.
2. **NSAIDs** inhibit the synthesis of prostaglandins, which are mediators of inflammation.
3. **Paracetamol** blocks the COX enzyme in the central nervous system but has minimal effect on peripheral inflammation.
4. **Local anesthetics** (e.g., procaine) block sodium channels, stopping the propagation of pain impulses.

New analgesics and recent research:

- **Suzetrigine:** Approved by the FDA in 2025, this new analgesic selectively inactivates sodium channels in peripheral nerves, preventing pain signals from reaching the brain. It provides pain relief similar to opioids but without the risk of addiction.
- **Localized pain relief:** In 2024, Australian scientists developed a prodrug that activates only at the site of pain. This prodrug reacts with reactive oxygen species present only at the pain site, providing targeted relief.

Recent developments in analgesic research include the creation of COX-2 selective inhibitors (e.g., meloxicam, celecoxib), gene therapy-based pain management technologies, and targeted receptor antagonists. Prodrug forms of medications are also being developed to enhance bioavailability.

Current challenges in the field of painkillers (analgesics):

1. **Complexity of individual pain assessment:** Each person perceives and describes pain differently, complicating the choice of analgesics. Subjective pain ratings often do not align with objective diagnostics.
2. **Tolerance to painkillers:** Prolonged use of opioids (e.g., morphine, fentanyl) leads to tolerance, requiring dose escalation and increasing side effect risks.
3. **Addiction and misuse:** The misuse of prescription opioids has led to an "opioid crisis" in the U.S. and other countries, with severe consequences.
4. **Side effects and toxicity:** Long-term use of NSAIDs can cause stomach ulcers, kidney failure, and cardiovascular risks. Overdosing on paracetamol can lead to liver necrosis.
5. **Safety in special populations:** Not all analgesics are safe for children, pregnant women, or the elderly. Careful dosing, precautions, and clinical trials are essential.
6. **Challenges in developing new analgesics:** Clinical trials to prove the efficacy and safety of new drugs take many years. Prodrugs, gene therapy, and peptide-based analgesics are still not widely used.
7. **Lack of multidisciplinary approaches to pain management:** Effective pain management requires not only medication but also psychological, rehabilitative, and physiotherapeutic strategies. However, many healthcare providers rely solely on pharmacological treatment.

Pain Relievers: Their Chemical Composition and Mechanism of Action on the Human Body

In this article, the chemical composition, classification, and biochemical mechanisms of action of analgesic drugs in reducing pain in the human body are highlighted. An analysis is provided using examples of drugs such as paracetamol, novocaine, and aspirin. Additionally, information about new analgesics based on the latest scientific research from 2024–2025, current problems in the field, suitable solutions, and global usage statistics of analgesics are included.

Pain Relievers in Medical Science

In the field of medicine, pain relievers (analgesics) are among the most essential medications used to reduce or completely eliminate pain. Pain is a physiological response of the body to pathological conditions and plays a key role in improving quality of life. Pain is one of the most important indicators of physiological and pathological states in the human body. In medical practice, various types of pain relievers are used to eliminate pain. These drugs have complex chemical structures studied in medical chemistry and act on the body through specific mechanisms.

Scientific Definition of Pain

The International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage." The development of pain involves nociceptors (pain receptors), the spinal cord, thalamus, and cerebral cortex.

Analgesics are divided into two main groups:

1. **Narcotic analgesics** (e.g., morphine, codeine) – act at the brain level and may lead to addiction.
2. **Non-narcotic analgesics** (e.g., paracetamol, novocaine, aspirin) – act on the peripheral and central nervous systems and do not cause addiction.

Examples:



- **Paracetamol (C₈H₉NO₂; 4-hydroxyphenylacetamide):** Used in medicine as an analgesic and antipyretic. Known as acetaminophen in some Western countries, it is the most widely used non-narcotic central analgesic globally. It is used for mild to moderate pain such as headaches, muscle pain, rheumatic pain, and fever due to colds. However, in large doses, it can damage the liver, kidneys, and circulatory system. It is listed on the WHO's list of essential medicines.
- **Novocaine (C₁₃H₂₀N₂O₂; 2-ethyl 4-aminobenzoate):** A local anesthetic with mild analgesic and broad therapeutic effects. It blocks impulse generation at sensory nerve endings and the transmission of impulses along nerve fibers. It blocks pain and other signals. Its effects progress from a cold sensation to loss of warmth, pain, and pressure sensations. It also relaxes smooth muscle spasms and partially inhibits the release of acetylcholine at presynaptic nerve endings, giving it mild ganglion-blocking properties. In high doses, it can disrupt neuromuscular conduction.
- **Aspirin (C₉H₈O₄; Acetylsalicylic acid):** Used in medicine to treat rheumatism, reduce fever, and relieve pain. In low doses, it has a blood-thinning effect and is used as an anticoagulant. Many elderly people take low-dose aspirin daily to prevent heart disease and stroke.

Mechanisms of Action:

1. **Opioid analgesics** bind to opioid receptors in the brain and spinal cord, blocking the transmission of pain signals.
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New Analgesics and Recent Research:

- **Suzetrigine:** Approved by the FDA in 2025, this new analgesic selectively inactivates sodium channels in peripheral nerves, preventing pain signals from reaching the brain. It reduces pain like opioids but without causing addiction.
- **Localized pain relief:** In 2024, Australian scientists developed a prodrug that is activated only at the site of pain by reactive oxygen species, making its effect localized and targeted.

Other innovations include COX-2 selective inhibitors (meloxicam, celecoxib), gene therapy-based pain management technologies, and targeted receptor antagonists. Prodrug forms are being developed to improve bioavailability and reduce side effects.

Key Challenges in Pain Management:

1. **Complexity in individual pain assessment:** Pain is subjective and varies from person to person. AI-based apps and imaging technologies (e.g., thermography, fMRI, EEG) can help improve objective pain assessment.
2. **Tolerance development:** Especially with opioids, long-term use can lead to tolerance, requiring higher doses and increasing side effects. Strategies include drug rotation, using the lowest effective dose, and combination therapy (e.g., with sedatives or antidepressants).
3. **Addiction and misuse:** Especially in countries like the USA, the opioid crisis has led to strict prescription controls and public health concerns. Prevention includes non-opioid methods (e.g., neurostimulation, physical therapy) and physician training.
4. **Side effects and toxicity:** Long-term NSAID use can lead to gastrointestinal bleeding, kidney failure, and cardiovascular risks. Paracetamol overdose can cause liver necrosis. Solutions include selective COX-2 inhibitors and protective therapies (e.g., PPIs).
5. **Safety in vulnerable groups:** Special dosing and guidelines are needed for children, pregnant women, and the elderly. Pharmacogenetics may help personalize safe and effective doses.
6. **Challenges in developing new analgesics:** Long clinical trials are needed. Biotechnological methods (e.g., gene therapy, monoclonal antibodies, peptides) and prodrug approaches are promising but not yet widespread.
7. **Lack of multidisciplinary approach:** Effective pain management requires not only medication but also psychological support, rehabilitation, and physiotherapy. Many doctors rely solely on pharmacological treatment.

Statistical Overview of Analgesic Use:

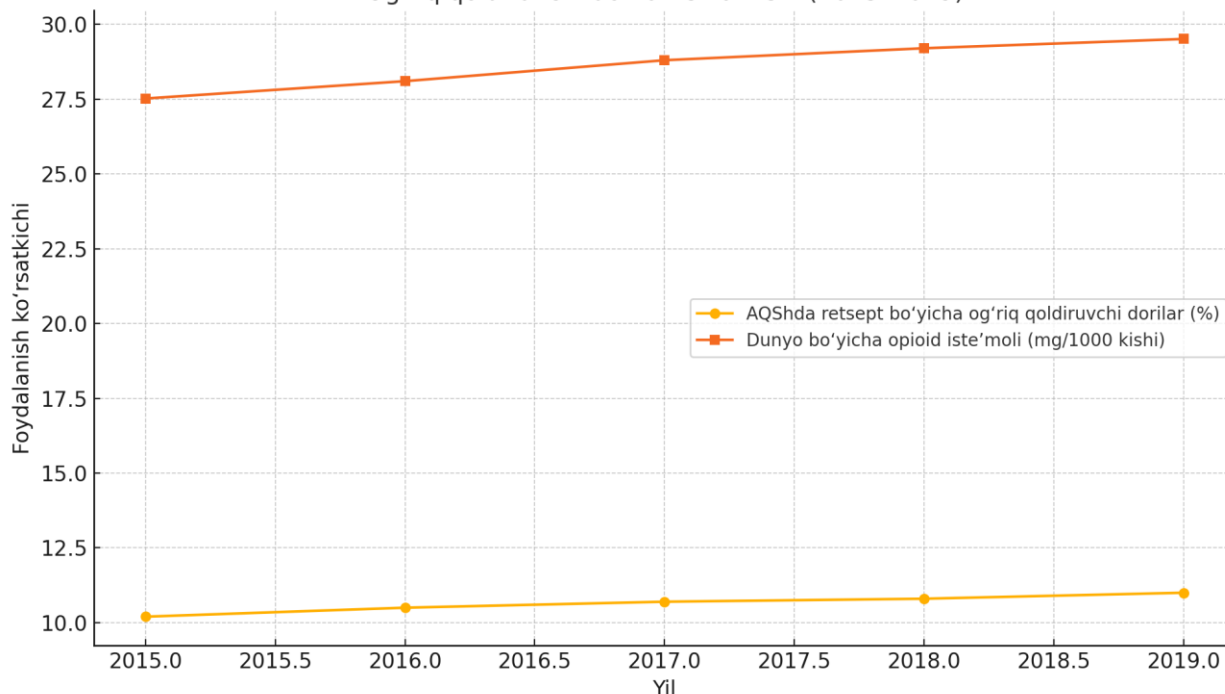
1. **Global Statistics:** According to the WHO, 70–80% of the global population experiences chronic pain at least once in their lifetime. Each year, around 10 million people are unable to work due to severe pain (Global Burden



of Disease Report, 2023). In 2024, paracetamol was the most used analgesic globally, with over 7 billion doses consumed (IQVIA 2024).

2. **Opioids and Consequences (USA):** In 2023, the U.S. recorded 80,411 deaths related to opioid overdose (CDC). On average, 220 people die each day from opioid overdose. In 2022, 12.5 million people in the U.S. used strong pain relievers without medical supervision (NIH).
3. **Risks of NSAIDs:** Long-term NSAID use causes over 15,000 deaths per year globally due to gastrointestinal bleeding. NSAIDs have been shown to increase cardiovascular risk by up to 30% in elderly patients (BMJ, 2022).
4. **Uzbekistan and Central Asia:** According to the Uzbekistan Ministry of Health (2023 report), NSAIDs and paracetamol are among the top-selling medications, making up 22% of all drug sales. In 2023, 1.3 million patients sought hospital care due to pain-related issues (MOH Statistics Bulletin, 2024). From 2024, pain assessment cards are being introduced in all outpatient clinics as part of a national plan.

Og'riq qoldiruvchi dorilar ishlatilishi (2015–2019)



CONCLUSION: From the perspective of medical chemistry, pain relievers influence important physiological processes in the human body. A deep understanding of their chemical composition and mechanisms of action contributes to effective pain reduction. Drugs such as paracetamol, novocaine, and aspirin are distinguished by their high therapeutic efficacy, though their side effects must also be taken into account. Recent scientific research has led to the development of new, more selective and safer analgesics, such as suzetrigine. This has paved the way for the introduction of new approaches to pain treatment in modern medicine. Therefore, ongoing scientific research on analgesics plays a crucial role in achieving a more precise understanding of their mechanisms of action.

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