Comparative Effectiveness of Nonsteroidal Anti-inflammatory Drugs and Glucocorticoids in Managing Postoperative Pain Syndrome

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Abstract: The purpose of this study was to investigate the effectiveness of nonsteroidal anti-inflammatory drugs and glucocorticosteroids in reducing postoperative pain syndrome. For this purpose, information about postoperative pain syndrome was searched in PubMed, ResearchGate, Scopus, Web of Science, and Google Scholar databases for 2016–2024. Depending on the duration, it is classified into acute (up to 3 months) and chronic (3 months or more). Postoperative pain syndrome occurs due to tissue damage, the development of an inflammatory process, and a violation of nerve conduction. Risk factors include severe preoperative pain; mental disorders; anxiety; comorbidities; low income; lack of social support. Effective treatment of postoperative pain syndrome is the main factor for further recovery and a comfortable life of the patient. High-quality anaesthesia helps to cope with pain even at the acute stage and prevents chronicity of the process. Nonsteroidal anti-inflammatory drugs and glucocorticoids in multimodal anaesthesia provide optimal anaesthesia in the postoperative period. They have anti-inflammatory, analgesic, and antiemetic effects. Prevention includes the appointment of preventive multimodal anaesthesia, the selection of minimally invasive surgical access to reduce the area of tissue injury; psychological support of patients at all stages of treatment; the appointment of rehabilitation interventions in the acute period. It was concluded that for adequate anaesthesia of postoperative pain, it is necessary to use nonsteroidal anti-inflammatory drugs and glucocorticoids as part of multimodal anaesthesia, because when used independently, they have an insufficient analgesic effect.

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Introduction

Postoperative pain syndrome is characterised by the appearance of pain in the postoperative period, provided that any other possible causes are excluded. This is a complex response to traumatic tissue and nerve damage during surgery. The syndrome was initially documented in 1999 and subsequently classified inside the International Classification of Diseases-11. Depending on the type and severity of surgery, the frequency of postoperative pain syndrome ranges from 7 to 80% (Viderman et al., 2023; Nuspekova et al., 2024). This leads to complete or partial disability of patients, sleep disorders, the development of a number of psychological problems, a decrease in the quality of life, and contributes to a high need for medical care, social, and economic costs. Postoperative pain increases the risk of further complications, prolongs the time of recovery and rehabilitation of patients. Acute postoperative pain is a normal body reaction in response to tissue and nerve damage (Navarro-Obeid et al., 2025). Nonetheless, inadequate therapy might lead to the onset of chronic postoperative pain, persisting for over 3 months. Therefore, it is important to immediately choose effective painkillers.

Pain perception is individual, depending on the pain threshold, mental state, and social context (Kaloshi et al., 2014; Efremov, 2025). A number of researchers have studied which surgical interventions increase the risk of postoperative pain syndrome. Thus, Kerimbayev et al. (2022), Viderman et al. (2023) and Nuspekova et al. (2024) noted that the main risk factors are breast removal, chest and pleural cavity opening operations, and amputations. The risk group for the syndrome includes young women; people with severe preoperative pain syndrome; preoperative opioid use; and the presence of severe mental disorders. Patients who have had isolated nerve damage are also at higher risk. When tissues are damaged due to surgery, changes occur in the somatosensory nervous system. The frequency and intensity of postoperative pain increase neuropathically. In patients after knee replacement who had severe postoperative pain for 1 month, the duration of the pain syndrome lasted up to 3 months.

The main problem is the lack of highly effective means of prevention and treatment of postoperative pain syndrome. Opioids quickly reduce severe pain, but their characteristic disadvantage is the development of tolerance and addiction. Stormholt et al. (2021), Hald and Møller (2024) and Zufferey et al. (2024) described those preventive measures include performing regional anaesthesia; performing epidural anaesthesia and paravertebral blockades during operations on the chest cavity and chest; and performing spinal anaesthesia during caesarean section. Multimodal postoperative pain relief (i.e., simultaneous administration of several drugs with a synergistic effect), which acts on different mechanisms of pain response, is an effective method of postoperative pain relief (Missori et al., 2016; Sakaguchi et al., 2024). Treatment should be started with nonsteroidal anti-inflammatory drugs (NSAIDs) and glucocorticosteroids, supplemented with opioids if necessary. Abdildin et al. (2023), Viderman et al. (2024) and Zhaksylyk et al. (2024) noted that the administration of ketamine, lidocaine, gabapentin, glucocorticoids, nonsteroidal anti-inflammatory drugs, and antidepressants during breast and chest surgery is important for pain management. Many researchers have already thoroughly investigated the effect of modern pharmacological drugs on the course and duration of postoperative pain syndrome.

The purpose of this study was to evaluate the importance of glucocorticoids and nonsteroidal anti-inflammatory drugs in reducing postoperative pain, regardless of the type of surgery performed. Tasks: to investigate and systematise the risk factors of postoperative pain syndrome; to describe the pathophysiology of postoperative pain syndrome; to analyse the main aspects of the intake, exchange, distribution, and conversion of nonsteroidal anti-inflammatory drugs and glucocorticoids; to describe the effect of these drugs on the patient's body; to investigate the effectiveness of NSAIDs and glucocorticoids in the occurrence of chronic postoperative pain syndrome as a result of performing common surgical interventions (caesarean section, thoracotomy, endoprosthetics, laparoscopic interventions, laparatomic interventions, spinal surgery).

Material and Methods

The first phase of the study from November 1 to November 30, 2024, was to perform a thorough structured systematic search for up-to-date information about postoperative pain syndrome, presented in the databases PubMed, ResearchGate, Scopus, Web of Science, and Google Scholar.

Throughout the investigation, all acquired papers were examined, emphasising material from peer-reviewed publications published between 2016 and 2024 in Polish, French, German, Spanish, and English. The necessary information was searched using a combined set of keywords: "postoperative pain syndrome", "acute pain", "chronic pain", "sensitisation", "nociception", "types of surgical

interventions", "laparotomy", "laparoscopy", "joint replacement", "breast removal", "thoracotomy", "caesarean section", "amputations", "prevalence of postoperative pain syndrome", "risk factors for postoperative pain syndrome", "pathogenesis of postoperative pain syndrome", "treatment of postoperative pain syndrome", "diagnosis of postoperative pain syndrome", "prevention of postoperative pain syndrome", "mechanism of action of nonsteroidal anti-inflammatory drugs", "mechanism of action of glucocorticoids", "effect of anti-inflammatory drugs on chronic postoperative pain syndrome".

The search yielded 2,500 papers. They were thoroughly evaluated, processed, and analysed by titles, annotations, relevancy, publication dates, and case study evidence level. To find more information, relevant paper links were examined and their content analysed. Next, duplicate and non-time-related papers were deleted. After then, research papers were reviewed using inclusion/exclusion criteria. Non-inclusion papers were immediately removed. This analysis excluded old, unsubstantiated, and irrelevant information, animal study data, and minimally invasive procedures as lumbar puncture (Figure 1).

Chronic postoperative pain syndrome epidemiology, aetiology, risk factors, processes of development, clinical picture, diagnosis, management, and prevention were covered in this study. Included were papers on new methodologies for studying chronic postoperative pain syndrome without regard to gender, age, race, region of residence, social status, disease course, or severity. Nonsteroidal anti-inflammatory medications and glucocorticoids were studied for their basic mechanisms, pharmacokinetics, pharmacodynamics, indications, contraindications, and adverse effects. The effects of nonsteroidal anti-inflammatory medications and glucocorticoids on persistent postoperative pain syndrome after thoracotomy, arthroplasty, amputation, laparotomy, and caesarean section were discussed. As a result of a thorough systematic selection process, 50 relevant research papers were obtained that fully met the necessary selected criteria. To avoid errors, the selected information sources were re-evaluated, processed, and verified.

Results and Discussion

Risk factors and pathophysiology of postoperative pain

The pathophysiology of postoperative pain generally encompasses a confluence of various elements. The initial event is tissue injury, characterised by cell membrane rupture, the release of intracellular contents, and the initiation of the inflammatory

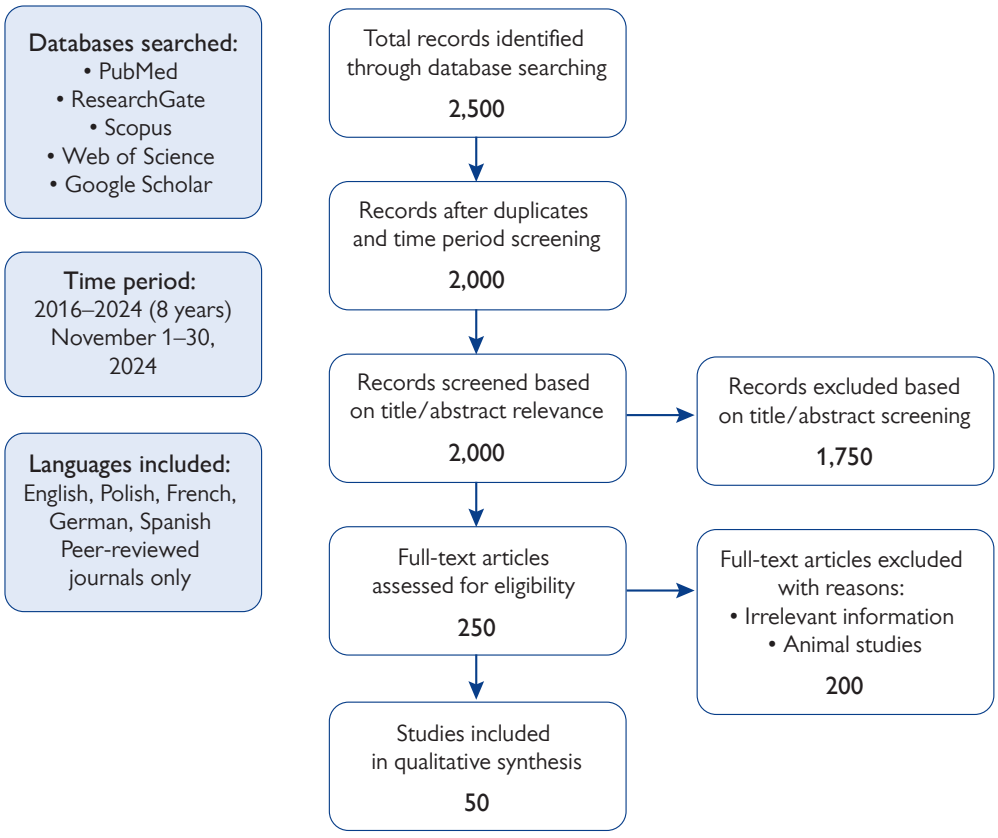

Figure 1: Systematic review selection process.

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Table 1: Risk factors for postoperative pain syndrome

Group	Representatives	Assessment scales
Psychological factors	Depressive disorders, anxiety, stress, fear of motor activity due to the risk of pain, sleep disorders, hypochondria, lack of effective psychological support.	Becks Depression Inventory (BDI), Hospital Anxiety and Depression Scale (HADS), Patient Health Questionnaire (PHQ-8), Minnesota Multiphasic Personality Inventory (MMPI).
Factors associated with pain	Severe pain syndrome in the area of the postoperative wound; the presence of a pain syndrome of a different localisation unrelated to the underlying disease; pain sensitisation; neuropathic causes of pain.	Visual Analog Scale (VAS), Western Ontario and McMaster Universities Osteoarthritis Index (VOMAC), Oswestry Disability Index (ODI).
Health-related factors	Concomitant diseases, severe general condition; obesity; fibromyalgia; disability; preoperative opioid use.	Pain Self-Efficiency Questionnaire (PSEQ), Modified Somatic Perception Scale (MSPQ), Oswestry Disability Index (ODI).
Features of social life	Low level of education; lack of adequate social support; loneliness; low economic income.	Client Satisfaction Questionnaire (CSQ).
Demographic factors	Female, young age, African American race.	–

Source: compiled by the authors based on Aliyev and Asik (2023), Pergolizzi et al. (2023), Sydora et al. (2024)

response. Due to the release of inflammatory mediators (cytokines, bradykinin, prostaglandins [PG]), nociceptors – pain receptors – are activated. PG play a major role in the development of pain. They increase the sensitivity of nociceptors to stimuli; enhance the inflammatory response and transmission of pain impulses to the spinal cord and brain by activating cyclooxygenase-2 (COX-2). Bradykinin increases vascular permeability, and interleukins (IL-1, IL-6) stimulate nerve endings. The accumulation of inflammatory exudate causes mechanical pressure on the nerve endings. Platelet activation and the production of free radicals increase the inflammatory process and damage nearby tissues. Due to prolonged irritation of pain receptors, their activation threshold decreases and peripheral sensitisation develops. Then the central nervous system is activated and central sensitisation occurs. This process is characterised by changes in the structures of the brain and spinal cord (SC), which leads to increased sensitivity to pain impulses. Prolonged irritation of peripheral nerves activates N-methyl-D-aspartate (NMDA) receptors in the dorsal horns. This leads to a decrease in the pain threshold and the occurrence of hyperalgesia and/or allodynia. Glial cells that secrete pro-inflammatory mediators are activated. Dysfunction of inhibitory pathways develops: there is an imbalance between excitatory and inhibitory neurotransmitters; the pain signal increases. In case of damage to nerve fibres, neuropathic pain occurs. Its signs include ectopic activity (the appearance of spontaneously active potentials at the site of damage); demyelination of the nerve (destruction of the myelin sheath, and the appearance of paresthesias). The autonomic nervous system affects the degree of pain expression in the postoperative period. When the sympathetic nerves are hyperactive, the pain increases by stimulating a-adrenergic receptors. An increase in the level of catecholamines leads to an increase in peripheral sensitisation. Reducing parasympathetic effects weakens anti-inflammatory defence mechanisms. Prolonged exposure to stress and/or sadness activates the limbic system, enhancing nociceptive pathway activity, while also inducing hormonal alterations characterised by elevated cortisol and epinephrine levels. With proper treatment of postoperative pain, it disappears at the stage of the acute process. However, with inefficiently selected analgesia, the condition is chronicled. It is characterised by long-term sensitisation; neuroplasticity (prolonged activation of central nervous system [CNS] structures contribute to the appearance of pathological nerve connections); the possibility of genetic predisposition. It is worth noting that if acute pain is a symptom, then chronic pain is already a disease.

In the course of the study, risk factors for postoperative pain syndrome were studied and classified (Table 1).

Psychological factors significantly impact postoperative pain outcomes. Conditions like depression and anxiety alter pain perception and coping abilities, while stress and fear of movement can increase pain sensitivity and delay recovery. Sleep disorders disrupt pain modulation and healing (Mirzakhmetova et al., 2024). Tools like the Beck Depression Inventory and Hospital Anxiety and Depression Scale help assess these factors. Pain-related factors include severe acute postoperative pain, pre-existing pain conditions, and pain sensitization, which can lead to chronic pain.

Neuropathic pain from nerve damage adds complexity. Assessment tools like the Visual Analog Scale and Oswestry Disability Index quantify these factors. Health-related factors such as comorbid diseases, obesity, fibromyalgia, and preoperative opioid use affect pain outcomes through physiological and pharmacological mechanisms. These can be evaluated using the Pain Self-Efficacy Questionnaire and Modified Somatic Perception Scale. Social life factors, including education level, social support, isolation, and economic status, influence pain perception and recovery. Lower education and inadequate social support can lead to increased stress and poorer pain outcomes. The Client Satisfaction Questionnaire can assess these factors. Demographic factors like female sex, African American race, and young age influence pain susceptibility through biological and social mechanisms. These factors are important for risk stratification and personalized pain management planning. Understanding these multifactorial risk factors highlights the need for a biopsychosocial approach to postoperative pain management. Thus, to reduce the intensity of postoperative pain, it is necessary to provide adequate preoperative anaesthesia and provide high-quality psychological assistance at all stages of treatment.

Characteristic features of postoperative pain syndrome, depending on the type of operation performed

The intensity of postoperative pain syndrome is significantly influenced by the type of operation, the type of anaesthesia, and the time that has elapsed since the surgical intervention. This is confirmed by many researchers, in particular (Aliyev and Asik, 2023; Pergolizzi et al., 2023). Researchers indicated that patients reported the greatest intensity of pain 0–1 days after laparotomy gynecological interventions (Sydora et al., 2024). When using general endotracheal and subarachnoid anaesthesia, patients complained of more severe pain compared to intravenous anaesthesia. The intensity of postoperative pain is directly proportional to the time of the operation. The use of premedication moderately reduces pain. In particular, the use of gabapentin in the preoperative period effectively reduces postoperative pain and the need for opioids.

Caesarean section is accompanied by severe postoperative pain, which negatively affects the psychological state of the mother, slows down recovery and return to daily activity (Arapbaevna et al., 2021; Machado et al., 2024). This condition is often underestimated or treated insufficiently for fear of the negative effects of analgesics on a woman's milk quality. As a result of the conducted research, Zeng et al. (2016) found that prescribing systemic NSAIDs reduced the severity of pain, reduced the need for opioids, and their overall negative effects on the body. Khezri et al. (2018), when comparing the effectiveness of NSAIDs and opioids, found a better analgesic effect when taking NSAIDs. Intravenous administration of dexamethasone, in addition to the analgesic effect, provided an antiemetic effect. The intensity of postoperative pain due to caesarean section significantly depends on the choice of the method of anaesthesia of the operation and surgical technique (Sagindykova et al., 2017). Preoperative administration of a long-acting intrathecal opioid (morphine 100 mcg) is recommended. The least traumatic is the Joel-Cohen incision and non-closing of the peritoneum.

Surgical intervention for artificial replacement of the hip and knee joints is very traumatic; acute pain that occurs after surgery can last up to 2 days without relief. More than 50% of patients in the early postoperative period complain of severe pain; and 30% – moderate (Anger et al., 2021). High-quality anaesthesia after total endoprosthetics provides the possibility of early postoperative mobility, optimal functioning of the limb, and reduces the risk of a number of postoperative complications. For this purpose, the use of multimodal analgesia is recommended. Ge et al. (2023) note that parecoxib as part of multimodal anaesthesia reduces acute postoperative pain in patients with hip and knee prosthetics; reduces cumulative opioid use without increasing the risk of side effects. Dexamethasone is used as part of treatment; this remedy also has an antiemetic effect.

Performing laparoscopic cholecystectomy significantly reduced the severity of postoperative pain compared to laparotomy. However, 20–40% of patients have pain syndrome after surgery, and 4–7% have it permanent. This is explained by a significant sympathetic-adrenal response during this surgical intervention. The study by Cao et al. (2024) found that compared to placebo and paracetamol, preoperative use of nerve blockades, ibuprofen, morphine, and pregabalin reduced pain intensity 2 hours after laparoscopic cholecystectomy. Taking ibuprofen reduced the incidence of postoperative nausea and vomiting compared to placebo, gabapentin, and tramadol. However, Karaaslan et al. (2019) indicated that the mechanism of pain after cholecystectomy contains visceral and sensory components. This explains the lower analgesic effect of NSAIDs compared to pregabalin and gabapentin (since NSAIDs affect only inflammation and, accordingly, somatic pain).

10–40% of patients who underwent surgical treatment on the lumbar spine developed

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postoperative pain syndrome with localisation in the back and legs in the postoperative period. Clinical signs included local pain, muscle spasms, numbness, and weakness. Pathogenesis includes a number of interrelated causes. Pathological compression of the spine accounts for up to 30% of the causes of chronic back pain. When the upper articular process is removed, the risk increases to 50%. Researchers Wang et al. (2021) note that inflammation of the spinal cord arachnoid membrane is also an important link in the pathogenesis of pain syndrome. Inflammatory mediators, in particular interleukin-8 and 6, prostaglandin E2 (PGE2) were found in postoperative drainage of patients. PGE2 causes the initial development of pain and subsequent sensitisation. Local pathophysiological processes due to intraoperative removal of the pulpous nucleus contribute to the development of pain syndrome. This is conditioned by the irritating effect of PGE2, cyclooxygenase 2, and nitric oxide on nearby nerve roots when the pulpous nucleus is exposed. Berta et al. (2017) indicate that inflammatory mediators enhance the regulation of N- and T-type calcium channels. This leads to sensitisation and hyperexcitability of dorsal root ganglion (DRG) neurons, which is associated with chronic pain and hypersensitivity. Central sensitisation of neurons in the posterior horn of the spinal cord is the main cause of chronic pain. This process is based on excessive stretching and compression of the dorsal horn, which leads to an increase in the amount of extracellular glutamate. Gliosis worsens chronic low back pain. Alshelh et al. (2022) confirmed that individuals with chronic low back pain exhibit elevated levels of brain translocator protein, a sign of glial activation. When examining spinal cord samples from patients, activation of astrocytes in the posterior horn of the spinal cord was detected.

Using a visually analogue scale (VAS), the patient can rate their pain from 0 (that is, nothing hurts at all) to 10 (the most severe pain). Postoperative pain is usually not limited only to the surgical site, but also includes local pain after performing spinal anaesthesia and injections, after tracheal intubation. The scale of clinical assessment of pain contains points regarding the change in pain, the effectiveness of its control, and the effect on sleep (Neumann-Podczaska et al., 2019; Tobis et al., 2020). Not all patients can correctly describe their symptoms, so appropriate assessment tools have been developed for them. For example, for people with dementia, pain in advanced dementia will be valid; for severe cognitive impairments – Dolopus-2, in intensive care – the Behavioural Pain Scale (BPS) (Aliyev and Asik, 2023; Pergolizzi et al., 2023). Information about the nature and origin of pain (visceral, neuropathic, nociceptive) is important for effective treatment. The pain syndrome will differ based on the context of surgical therapy, whether it is scheduled or urgent. A differentiated approach to prescribing painkillers means selecting a drug based on the mechanism of pain occurrence, its characteristics, and individual characteristics of the patient. The main requirements for treatment are the need for the fastest and most complete anaesthesia; the use of drugs with proven effectiveness. The choice of adequate methods of analgesia should begin at the stage of planning the operation. For this purpose, preventive multimodal anaesthesia is used. This tactic involves blocking the pain sensation centre before surgery occurs, in order to suppress the sensitisation of the pain centre. Multimodal anaesthesia covers the use of drugs that act on different parts of the anatomical pain pathways (Figure 2). Wang et al. (2020) noted that the use of multimodal analgesia to reduce postoperative pain in liver donation reduced the need for opioids by 50%. It is advisable to combine drugs with different mechanisms of action, but synergistic effects to reduce the dosage and, accordingly, reduce the frequency of side effects. The combination of effective preoperative, intraoperative, and postoperative anaesthesia reduces the intensity of pain, the risk of postoperative bleeding, and reduces the need for anaesthetics. Multimodal anaesthesia is based on nonsteroidal anti-inflammatory drugs as the main group with a strong analgesic effect (Abushanab and Al-Badriyeh, 2021; Dieu et al., 2021; Jiang and Ye, 2022).

In the study by Chang et al. (2021) described the efficacy of NSAIDs as the main analgesics administered before, during, and after surgery. They inhibit cyclooxygenase-1 and cyclooxygenase-2 (COX-1 and COX-2), which regulates prostaglandin synthesis. The release of pro-inflammatory cytokines (interleukin-1

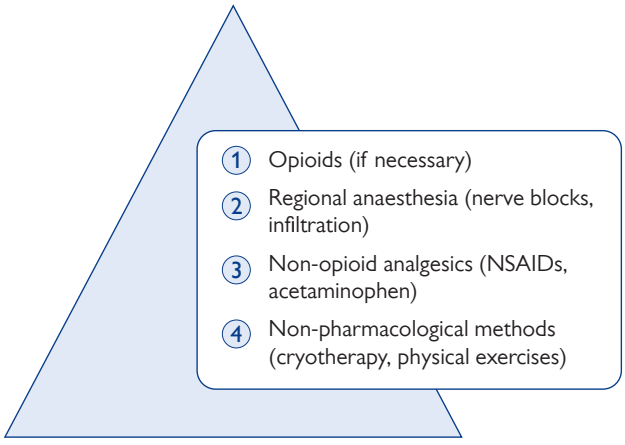

Figure 2: Components of multimodal anaesthesia.
Source: compiled by the authors based on Hobelmann and Huhn (2021), Wu et al. (2023).

and tumour necrosis factor-alpha) slows down, white blood cell migration, phagocyte activation, and postoperative oedema decrease. Accordingly, due to the suppression of the inflammatory response, the activity and sensitisation of peripheral nociceptors is inhibited; the duration and intensity of pain decreases. Penetrating the blood-brain barrier, NSAIDs block COX-2 activity in the central nervous system, suppressing central sensitisation. It should be emphasised that central sensitisation underlies the development of chronic pain syndrome. That is, this group of drugs is a pathogenetic treatment for pain. The advantages are the absence of influence on consciousness, haemodynamics and respiratory rate, normalisation of reactions of the autonomic nervous system. Small and Laycock (2020) investigated that NSAID administration reduces the need for morphine in the postoperative period. However, this group of drugs has a number of side effects. Non-selective NSAIDs block COX-1 and inhibit thromboxane A2 (regulates platelet clotting). All NSAIDs are contraindicated in patients after coronary artery bypass grafting. But, if necessary, after cardiac operations, preference should be given to non-selective NSAIDs prescribed in the short term. With prolonged use, they inhibit the protective secretion of mucus bicarbonate in the gastric mucosa. Nonsteroidal anti-inflammatory drugs reduce glomerular pressure by narrowing their afferent arterioles; reduce creatinine clearance by 16 ml/min on the first day after surgery compared to placebo (Table 2). At the same time, there are no statistically significant differences in serum creatinine levels, urinary excretion, and cases of postoperative renal failure. Therefore, in individuals with normal renal function, controlled dosed administration of NSAIDs does not cause renal failure. This is also confirmed in a study by Chang et al. (2021), which states that the degree of nephrotoxicity directly depends on the level of kidney damage. NSAIDs affect the degree of healing of bones, tendons, and ligaments (in particular, selective COX-2 inhibitors).

Ketorolac is a highly effective analgesic; it quickly reduces peripheral sensitisation. The disadvantage is the high risk of adverse reactions from the gastrointestinal tract, in particular bleeding, so the drug should be prescribed for a short time together with proton pump inhibitors. Patients who were prescribed low doses of ketorolac (>30 mg) had a significantly lower risk of side effects. Compared to other analgesics (opioids, acetaminophen), taking ketorolac did not increase the risk of postoperative bleeding and, in particular, bleeding after knee replacement surgery.

Diclofenac is characterised by high anti-inflammatory activity; effectively reduces postoperative pain and inflammation (Latka et al., 2021, 2023). For inflammation caused by trauma, it reduces swelling and the recovery period of damaged joints, ligaments, tendons, and muscles.

The main advantage of ibuprofen, compared to representatives of its group of drugs, is a relatively low risk of side effects. Cao et al. (2024) noted that preoperative intravenous administration of ibuprofen reduces stress and inflammatory response by inhibiting the release of catecholamines, cortisol, and cytokines as a result of adult cholecystectomy. It was also reported that the use of this drug is safe in patients undergoing soft tissue surgery; it was noted that short-term administration of ibuprofen did not cause severe side effects, including gastrointestinal bleeding. However, it is worth noting that when ibuprofen was prescribed for a period of 2 weeks before hip surgery, the volume of perioperative blood loss increased. Therefore, NSAIDs are not recommended before surgery.

Celecoxib inhibits COX-2 synthesis. Due to its mechanism of action, it is a highly effective drug for controlling postoperative pain in patients at risk of gastrointestinal bleeding. The study described that administration of celecoxib after arthroscopic restoration of the rotator cuff increased the frequency of repeated ruptures compared to ibuprofen and tramadol (Chang et al., 2021). It is contraindicated in persons with disorders of the cardiovascular system.

Table 2: Classification of nonsteroidal anti-inflammatory drugs

Characteristics	Nonsteroidal anti-inflammatory drugs		
By selectivity	Non-selective COX-1 and COX-2 inhibitors (ibuprofen, diclofenac, ketorolac).	Selective COX-2 inhibitors (celecoxib).	Highly selective COX-2 inhibitors (lumiracoxib).
By duration of action	Short-acting (up to 6 hours): ibuprofen, ketorolac, diclofenac.	Medium duration (6–12 hours): naproxen, meloxicam.	Long-acting (more than 12 hours): piroxicam.
By pharmacological action	Drugs with mainly anti-inflammatory effects (diclofenac, indomethacin).	Drugs with mainly analgesic effects (ketorolac, aspirin).	Drugs with mainly antipyretic effects (ibuprofen, naproxen).

Source: compiled by the authors based on McQuay et al. (2016), Gasbjerg et al. (2022), Malik et al. (2024)

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Inhibits water reabsorption in collecting tubes, preventing the action of antidiuretic hormone.

Parecoxib is an injectable selective COX-2 inhibitor. The mechanism of action is to reduce central sensitivity and inflammation of peripheral nociceptors. Preoperative administration of this drug significantly reduced postoperative cumulative opioid use and did not increase the risk of adverse reactions. It does not cause prolongation of bleeding time and does not disrupt the normal functioning of the gastric mucosa. It is an effective tool for orthopedic, obstetric, and general surgical interventions. When replacing joints, it performs a protective function, improves the immune response, and reduces the frequency of postoperative chills and delirium. When performing open liver resection, parecoxib was administered intravenously 40 mg half an hour before induction, and 40 mg every 12 hours for the first 2 days after surgery. Patients had lower VAS rates at rest after 2, 6, 12, and 24 hours and a lower need for fentanyl. Gau et al. (2023) described that administration of lidocaine and parecoxib after thyroidectomy provided adequate anaesthesia with minimal side effects (Hardman et al., 2021; Han et al., 2024).

Descetoprofen is structurally the active S(+)-enantiomer of ketoprofen. Due to this, there is no risk of side effects associated with the action of the R-enantiomer of ketoprofen. The incidence of gastrointestinal bleeding, nausea, and vomiting is significantly lower compared to representatives of the same pharmacological group. Inhibits cyclooxygenase, inhibits the conversion of arachidonic acid to cyclic ENDOPEROXIDES PGG2 and PGH2, which form prostaglandins PGE1, PGE2, PGF2a, PGD2, and prostacyclin PGI2 and thromboxanes (Tha2 and Thxv2). McQuay et al. (2016) indicated that the concomitant treatment of oral dexketoprofen 25 mg and tramadol 75 mg was more efficacious than the separate administration of both agents, particularly in the context of surgical intervention for total hip replacement.

Paracetamol belongs to analgesics-antipyretics, but is often prescribed in addition to NSAIDS as a component of multimodal anaesthesia. The mechanism of action is to block cyclooxygenase at the central level, affecting the pain centres and thermoregulation. With multimodal anaesthesia, this drug provides an opioid-sparing effect. McQuay et al. (2016) described a statistically significant reduction in morphine use with additional paracetamol administration. The intravenous injection of paracetamol correlates with a diminished occurrence of postoperative nausea and vomiting, attributed to enhanced pain management. Therefore, the use of paracetamol reduces pain and reduces dosages of other painkillers.

Glucocorticosteroids are synthetic or natural analogues of hormones that are produced by the adrenal cortex under physiological conditions. They are characterised by a pronounced anti-inflammatory, immunosuppressive, and metabolic effect. This group of pharmaceutical products is classified according to a number of characteristics (Table 3). The anti-inflammatory effect is due to inhibition of pro-inflammatory cytokines, induction of anti-inflammatory cytokines, decreased prostaglandin synthesis, and excitability of nerve cells (Mao et al., 2016; Silva et al., 2023; Han et al., 2024).

Methylprednisolone, compared to prednisone, has a more pronounced anti-inflammatory effect and retains less water and sodium. Reduces the number of immunoactive cells at the site of inflammation; reduces vasodilation; stabilises lysosomal membranes; inhibits phagocytosis; reduces prostaglandin production. Preoperative administration of methylprednisolone 125 mg reduced the severity of postoperative pain in the first 24 hours (Gupta et al.,

Table 3: Classification of glucocorticosteroids

Indicator	Glucocorticosteroids		
By origin	Natural (hydrocortisone).	Synthetic (prednisone, dexamethasone, betamethasone).	–
By activity spectrum	Glucocorticoid activity (predominant effect on the metabolism and conversion of proteins, fats, carbohydrates): prednisone.	Mineralocorticoid activity (predominant effect on water-electrolyte balance): hydrocortisone.	–
By action	Topical (topical use for skin and eye lesions): hydrocortisone.	Systemic (if necessary, effects on the entire body): prednisone, dexamethasone.	–
By duration of action	Short (up to 12 hours): hydrocortisone, cortisone.	Average (12–36 hours): prednisone.	Prolonged (>36 hours): dexamethasone.

Source: compiled by the authors based on Ross et al. (2021), Maloney et al. (2022), Huang et al. (2023)

2020; Arslan and Ünal Çevik, 2022; Ranjbari and Alimohammadi, 2024).

Prednisone is characterised by anti-inflammatory, immunosuppressive, and anti-allergic effects. The immunosuppressive effect is associated with inhibition of cytokine excretion from lymphocytes and macrophages (Shetty et al., 2020; Coşarcan et al., 2022; Vilai et al., 2023). The anti-inflammatory effect involves the suppression and release of inflammatory mediators by immunocompetent cells, reducing capillary permeability, and stabilising the membranes of mast cells. Anger et al. (2021) noted that prescribing 10 mg of prednisone perioperatively reduced VAS pain scores by 2 points, reduced the need for opioid prescribing in the first 24 hours, and improved acute recovery rates.

Dexamethasone has a pronounced anti-inflammatory, anti-allergic, and antipruritic effect (Lisiecka, 2024a). It affects all stages of the inflammatory process. It reduces the permeability of blood vessels, slows down the migration of white blood cells and phagocytes, the release of kinins, and the development of antibodies. Studies of intra-articular injections of glucocorticoids after total knee replacement revealed higher efficacy of the corticosteroid group compared to non-corticosteroids. This treatment reduced the severity of pain at rest and during movement. Two oral doses of dexamethasone as an adjunct to multimodal pain management with paracetamol, ibuprofen, and local infiltration analgesia reduced morphine intake and the severity of pain after knee replacement (Kerimbayev et al., 2022). Caution should be exercised when prescribing dexamethasone to people with diabetes mellitus, because their side effect is an increase in blood glucose.

Thus, the main advantages of NSAIDs in postoperative pain syndrome are effective suppression of inflammation, rapid reduction of pain, reduction of the need for opioid analgesics, and reduction of the duration of the rehabilitation period. Glucocorticoids are an effective component of multimodal anaesthesia, which, in addition to analgesic effect, have an antiemetic effect (Lisiecka, 2024b). The use of these groups of drugs in the preoperative and postoperative stages significantly reduced the postoperative need for opioid analgesics. It is necessary to consider the concomitant diseases of patients and their age, because nonsteroidal anti-inflammatory drugs and glucocorticoids have cardiotoxic, nephrotoxic, haepatotoxic effects. It is necessary to correctly choose the drug in accordance with the surgical treatment performed. Prevention includes the use of multimodal anaesthesia at the preoperative, intraoperative, and postoperative stages; selection of minimally invasive surgical access to reduce the area of tissue injury; psychological support and support of patients at all stages of treatment; appointment of rehabilitation interventions in the acute period.

In the postoperative period, NSAIDs and glucocorticosteroids are widely used to reduce pain and inflammation. However, their long-term use can lead to a number of serious complications. For example, NSAIDs can cause impaired renal function, which is manifested by decreased glomerular filtration rate and risk of acute renal failure. In addition, these drugs are often associated with gastrointestinal problems such as ulcers and bleeding due to their ability to reduce the production of protective mucus in the stomach. Cardiovascular risks are also increased with long-term use of NSAIDs, including an increased likelihood of myocardial infarction and stroke, especially in patients with a predisposition to cardiovascular disease. Glucocorticosteroids, in turn, can cause metabolic changes such as hyperglycaemia, weight gain and osteoporosis, which is particularly relevant in their long-term use. These drugs also contribute to increased blood pressure and increased risk of infections due to their immunosuppressive action. Thus, despite their efficacy in the short term, both NSAIDs and glucocorticosteroids require cautious use and careful monitoring during long-term use to minimise the risk of complications and ensure patient safety.

Conclusion

The effectiveness of nonsteroidal anti-inflammatory drugs and glucocorticosteroids in postoperative pain management has been conclusively established through extensive research across various surgical procedures. NSAIDs demonstrate superior analgesic efficacy by targeting cyclooxygenase pathways, thereby reducing prostaglandin synthesis and inflammatory responses while simultaneously addressing both peripheral and central sensitization mechanisms. Glucocorticosteroids complement this approach through their potent anti-inflammatory and antiemetic properties, contributing to comprehensive symptom control in the postoperative period.

The integration of these pharmaceutical agents within multimodal anaesthesia protocols represents the current gold standard for postoperative pain management. This approach capitalizes on synergistic effects while minimizing individual drug dosages and associated adverse reactions. The evidence consistently supports the opioid-sparing effects of NSAID and glucocorticosteroid combinations, which is particularly significant given the ongoing concerns regarding opioid dependence and tolerance.

However, the clinical application of these agents requires careful consideration of patient-specific factors and potential contraindications. The documented risks of gastrointestinal, cardiovascular, and renal complications with NSAIDs, alongside the metabolic and immunosuppressive effects of glucocorticosteroids, necessitate judicious prescribing practices and ongoing monitoring. The selection of specific agents within these drug classes should be tailored to individual patient profiles, surgical procedures, and risk-benefit assessments.

The implementation of preventive multimodal anaesthesia strategies, beginning in the preoperative period and extending through the entire perioperative continuum, represents a paradigm shift toward proactive rather than reactive pain management. This approach, combined with appropriate psychological support and minimally invasive surgical techniques where feasible, offers the greatest potential for preventing the transition from acute to chronic postoperative pain.

The limitations of the presented study are a small number of papers describing the independent analgesic effect of NSAIDs/glucocorticoids in the postoperative period, because they mainly investigate the analgesic effect of these drugs as part of multimodal anaesthesia. Future research should continue to refine optimal dosing regimens, timing of administration, and drug combinations while exploring novel therapeutic targets and delivery methods. The development of personalized pain management protocols based on individual risk stratification and genetic factors may further enhance outcomes while minimizing adverse effects.

References

Abdildin, Y., Tapinova, K., Salamat, A., Shaimakhanov, R., Aitbayev, A., Viderman, D. (2023) Rectus sheath block in abdominal surgery: A systematic review with meta-analysis. *Rom. J. Anaest. Intensive Care* **30(1)**, 43–50.

Abushanab, D., Al-Badriyeh, D. (2021) Efficacy and safety of ibuprofen plus paracetamol in a fixed-dose combination for acute postoperative pain in adults: Meta-analysis and a trial sequential analysis. *CNS Drugs* **35(1)**, 105–120.

Aliyev, D., Asik, I. (2023) Postoperative chronic pain syndrome and risk factors in patients with breast surgery. *J. Coll. Physicians Surg. Pak.* **33(6)**, 609–615.

Alshelh, Z., Brusaferri, L., Saha, A., Morrissey, E., Knight, P., Kim, M., Zhang, Y., Hooker, J. M., Albrecht, D., Torrado-Carvajal, A., Placzek, M. S., Akeju, O., Price, J., Edwards, R. R., Lee, J., Sclocco, R., Catana, C., Napadow, V., Loggia, M. L. (2022) Neuroimmune signatures in chronic low back pain subtypes. *Brain* **145(3)**, 1098–1110.

Anger, M., Valovska, T., Beloeil, H., Joshi, G. P., Van de Velde, M., Raeder, J.; PROSPECT Working Group* and the European Society of Regional Anaesthesia and Pain Therapy (2021) PROSPECT guideline for total hip arthroplasty: A systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia* **4(1)**, 1082–1097.

Arapbaevna, K. Z., Ardak, A., Abzhanovna, A. G., Bahitkerevna, D. A., Uringalievna, B. A., Izbasarovna, K. E., Malikovna, D. A., Erbolovna, D. A. (2021) Modern diagnostic approaches for early detection of antiphospholipid syndrome. *Arch. Venez. Farmacol. Ter.* **40(2)**, 178–186.

Arslan, D., Ünal Çevik, I. (2022) Interactions between the painful disorders and the autonomic nervous system. *Agri* **34(3)**, 155–165.

Berta, T., Qadri, Y., Tan, P.-H., Ji, R. R. (2017) Targeting dorsal root ganglia and primary sensory neurons for the treatment of chronic pain. *Expert Opin. Ther. Targets* **21(7)**, 695–703.

Cao, L., Yang, T., Hou, Y., Yong, S., Zhou, N. (2024) Efficacy and safety of different preemptive analgesia measures in pain management after laparoscopic cholecystectomy: A systematic review and network meta-analysis of randomized controlled trials. *Pain Ther.* **13(6)**, 1471–1497.

Chang, R. W., Tompkins, D. M., Cohn, S. M. (2021) Are NSAIDs safe? Assessing the risk-benefit profile of nonsteroidal anti-inflammatory drug use in postoperative pain management. *Am. Surg.* **87(6)**, 872–879.

Coşarcan, S. K., Yavuz, Y., Doğan, A. T., Erçelen, Ö. (2022) Can postoperative pain be prevented in bariatric surgery? Efficacy and usability of fascial plane blocks: A retrospective clinical study. *Obes. Surg.* **32(9)**, 2921–2929.

Dieu, A., Huynen, P., Lavand'homme, P., Beloeil, H., Freys, S., Pogatzki-Zahn, E., Joshi, G., Van de Velde, M.; PROSPECT Working Group of the European Society of Regional Anaesthesia and Pain Therapy (ESRA) (2021) Pain management after open liver resection: Procedure-specific postoperative pain management (PROSPECT) recommendations. *Reg. Anesth. Pain Med.* **46(5)**, 433–445.

Efremov, A. (2025) The fear primacy hypothesis in the structure of emotional states: A systematic literature review. *Psychol. Rep.* (Epub ahead of print)

Gasbjerg, K., Hägi-Pedersen, D., Lunn, T., Laursen, C., Holmqvist, M., Vinstrup, L., Ammitzboell, M., Jakobsen, K., Jensen, M., Pallesen, M., Bagger, M., Lindholm, P., Pedersen, N., Schrøder, H., Lindberg-Larsen, M., Nørskov, A., Thybo, K., Brorson, S., Overgaard, S., Jakobsen, J., Mathiesen, O. (2022) Effect of dexamethasone as an analgesic adjuvant to multimodal pain treatment after total knee arthroplasty: Randomised clinical trial. *BMJ* **4(376)**, e067325.

Gau, T. P., Wu, S. H., Huang, J. M., Lu, W. L., Huang, T. Y., Lu, I. C., Wu, C. W. (2023) Multimodal analgesia with local wound infiltration and intravenous parecoxib for thyroidectomy. *Medicina (Kaunas)* **59(5)**, 855.

Ge, Z., Li, M., Chen, Y., Sun, Y., Zhang, R., Zhang, J., Bai, X., Zhang, Y., Chen, Q. (2023) The efficacy and safety of parecoxib multimodal preemptive analgesia in artificial joint replacement: A systematic review and meta-analysis of randomized controlled trials. *Pain Ther.* **12(4)**, 1065–1078.

Gupta, R., Van de Ven, T., Pyati, S. (2020) Post-thoracotomy pain: Current strategies for prevention and treatment. *Drugs* **80(16)**, 1677–1684.

Hald, P. P., Møller, A. M. (2024) Pain management in total knee arthroplasty. *Ugeskr. Laeger* **186(25)**, V10230664. (in Danish)

Han, C., Gan, D., Meng, C., Qiu, Y., Hao, T. (2024) Efficacy and safety of intra-articular glucocorticoid injection for postoperative pain

control after knee arthroscopy: A systematic review. *J. Orthop. Surg. Res.* **19(1)**, 736.

Hardman, M., Olsen, D., Amundson, A. (2021) Multimodal analgesia decreases postoperative opioid consumption in living liver donation. *Mayo Clin. Proc. Innov. Qual. Outcomes* **5(3)**, 583–589.

Hobelmann, J. G., Huhn, A. S. (2021) Comprehensive pain management as a frontline treatment to address the opioid crisis. *Brain Behav.* **11(11)**, e2369.

Huang, H. J., Dang, H. H., Mamtimin, M., Yang, G., Zhang, X., Wang, J. Q. (2023) Hip arthroscopy for femoroacetabular impingement syndrome shows good outcomes and low revision rates, with young age and low postoperative pain score predicting excellent 5-year outcomes. *Arthroscopy* **39(2)**, 285–292.

Jiang, B., Ye, S. (2022) Pharmacotherapeutic pain management in patients undergoing laparoscopic cholecystectomy: A review. *Adv. Clin. Exp. Med.* **31(11)**, 1275–1288.

Kaloshi, G., Roji, A., Seferi, A., Cakani, B., Bushati, T., Roci, E., Petrela, M. (2014) Spinal dissemination of intracranial glioblastoma in bevacizumab era: A potential bevacizumab-induced mechanism. *Acta Inform. Med.* **22(2)**, 142–144.

Karaaslan, E., Akbas, S., Ozkan, A., Zayman, E. (2019) Effects of preemptive intravenous paracetamol and ibuprofen on headache and myalgia in patients after electroconvulsive therapy: A placebo-controlled, double-blind, randomized clinical trial. *Medicine (Baltimore)* **98(51)**, e18473.

Kerimbayev, T., Kenzhegulov, Y., Tuigynov, Z., Aleinikov, V., Urunbayev, Y., Pan, A., Abishev, N., Oshayev, M., Baiskhanova, D., Solodovnikov, M., Akshulakov, S. (2022) Transforaminal endoscopic discectomy under general and local anesthesia: A single-center study. *Front. Surg.* **19(9)**, 873954.

Khezri, M., Mosallaei, M., Ebtehaj, M. (2018) Comparison of preemptive effect of intravenous ketorolac versus meperidine on postoperative shivering and pain in patients undergoing cesarean section under spinal anesthesia: A prospective, randomized, double-blind study. *Caspian J. Intern. Med.* **9(2)**, 151–157.

Latka, K., Kozlowska, K., Waligora, M., Kolodziej, W., Olbrycht, T., Chowaniec, J., Hendryk, S., Latka, M., Latka, D. (2021) Efficacy of DiscoGel in treatment of degenerative disc disease: A prospective 1-year observation of 67 patients. *Brain Sci.* **11(11)**, 1434.

Latka, K., Kozlowska, K., Waligora, M., Kolodziej, W., Latka, D. (2023) Effect of DiscoGel treatment of the intervertebral disc at MRI. *Clin. Radiol.* **78(12)**, 928–934.

Lisiecka, M. Z. (2024a) Evolution, mechanism of action, and clinical applications of three generations of antihistamines. *Innovaciencia* **12(1)**, e3651.

Lisiecka, M. Z. (2024b) Side effects and hypersensitivity reactions to corticosteroids. *Med. Perspekt.* **29(1)**, 95–104.

Machado, J. R. U., Maldonado, C. B. V., Zambrano, N. S. B. (2024) Unnecessary caesarean section?: A bioethical vision at this birth modality in Chile and Venezuela. *Gac. Med. Caracas* **132(1)**, 208–224.

Malik, A., Elshazly, T., Pokuri, K., Apai, C., Rothkrug, A., Hasoon, J., Chung, M., Ye, Z., Bhayani, S., Kaye, S., Liu, H., Lang, M., Yong, R. J., Donjow, A., Varrassi, G., Robinson, G. (2024) Virtual reality for postoperative pain management: A review of current evidence. *Curr. Pain Headache Rep.* **28(12)**, 1307–1319.

Maloney, J., Wie, C., Pew, S., Covington, S., Maita, M., Kozinn, R., Sabin, M., Freeman, J., Kraus, M., Strand, N. (2022) Post-thoracotomy pain syndrome. *Curr. Pain Headache Rep.* **26(9)**, 677–681.

Mao, Y., Wu, L., Ding, W. (2016) The efficacy of preoperative administration of gabapentin/pregabalin in improving pain after total hip arthroplasty: A meta-analysis. *BMC Musculoskelet. Disord.* **17(1)**, 373.

McQuay, H. J., Moore, R. A., Berta, A., Gainutdinovs, O., Fülesdi, B., Porvaneckas, N., Petronis, S., Mitkovic, M., Bucsi, L., Samson, L., Zegunis, V., Ankin, M., Bertolotti, M., Pizà-Vallespir, B., Cuadripani, S., Contini, M., Nizzardo, A. (2016) Randomized clinical trial of dexketoprofen/tramadol 25 mg/75 mg in moderate-to-severe pain after total hip arthroplasty. *Br. J. Anaesth.* **116(2)**, 269–276.

Mirzakhmetova, D., Kamkhen, V., Akhmetzhanova, Z., Sarmuldayeva, S., Ayazbekov, A., Iskakova, F. (2024) Predictors associated with night sleep disturbance among breastfeeding women. *Prev. Med.* **185**, 108011.

Missori, P., Domenicucci, M., Paolini, S., Mancarella, C., Tola, S., D'Elia, A., Marotta, N., Seferi, A., Esposito, V. (2016) Emergency decompressive craniectomy after removal of convexity meningiomas. *Surg. Neurol. Int.* **7(1)**, 193098.

Navarro-Obeid, J., Lhoeste-Charris, Á., Orozco Santander, M., González, C. Á., Delbono, L. C., Sierra, B. S., Zurita-Caraballo, M. (2025) A systematic review of psychological and physical factors associated with fibromyalgia. *Gac. Med. Caracas* **133(Supl. 1)**, S273–S285.

Neumann-Podczaska, A., Tobis, S., Yermukhanova, L., Wieczorowska-Tobis, K. (2019) Pain in advanced stages of dementia: The perspective of medical students. *Medicina (Kaunas)* **55(5)**, 116.

Nuspekova, D., Doskaliyev, A., Dzhumabekov, A., Akilov, K., Dossan, A. (2024) Application of biotechnologies in the treatment of haemorrhoidal disease and optimisation of patient management. *Prz. Gastroenterol.* **19(2)**, 127–134.

Pergolizzi, J., LeQuang, J., Magnusson, P., Varrassi, G. (2023) Identifying risk factors for chronic postsurgical pain and preventive measures: A comprehensive update. *Expert Rev. Neurother.* **23(12)**, 1297–1310.

Ranjbari, F., Alimohammadi, E. (2024) Unveiling the potential impact of vitamin C in postoperative spinal pain. *Chin. Neurosurg. J.* **10(1)**, 16.

Ross, J., Cole, C., Lo, W., Ura, M. (2021) Postoperative pain in thoracic surgical patients: An analysis of factors associated with acute and chronic pain. *Heart Lung Circ.* **30(8)**, 1244–1250.

Sagindykova, A. A., Bazylbekova, Z. O., Sagindykova, B. A. (2017) Ways of prognosis and reduction of obstetric and perinatal complications at pregnancy chronic pyelonephritis. *Biomed. Pharmacol. J.* **10(2)**, 535–547.

Sakaguchi, T., Gunjotikar, S., Tanaka, M., Komatsubara, T., Latka, K., Ekade, S. J., Prabhu, S. P., Takamatsu, K., Yasuda, Y., Nakagawa, M. (2024) Evaluation and rehabilitation after adult lumbar spine surgery. *J. Clin. Med.* **13(10)**, 2915.

Shetty, V., BhanuPrakash, B., Yadav, A., Kishore, N., Menon, A. (2020) Do regional nerve blocks before bimaxillary surgery reduce postoperative pain? *J. Oral Maxillofac. Surg.* **78(5)**, 724–730.

Silva, A., Costa, B., Castro, I., Mourão, J., Vale, N. (2023) New perspective for drug-drug interaction in perioperative period. *J. Clin. Med.* **12(14)**, 4810.

Small, C., Laycock, H. (2020) Acute postoperative pain management. *Br. J. Surg.* **107(2)**, e70–e80.

Stormholt, E., Steiness, J., Derby, C., Larsen, M., Maagaard, M., Mathiesen, O. (2021) Paracetamol, non-steroidal anti-inflammatory drugs and glucocorticoids for postoperative pain: A protocol for a systematic review with meta-analysis and trial sequential analysis. *Acta Anaesthesiol. Scand.* **65(10)**, 1505–1513.

Sydora, B., Whelan, L., Abelseth, B., Brar, G., Idris, S., Zhao, R., Leonard, A., Rosenbloom, B., Clarke, H., Katz, J., Beesoon, S., Rasic, N. (2024) Identification of presurgical risk factors for the development of chronic postsurgical pain in adults: A comprehensive umbrella review. *J. Pain Res.* **17**, 2511–2530.

Tobis, S., Neumann-Podczaska, A., Yermukhanova, L., Sultanova, G., Kurmanalina, G., Kimatova, K., Dworacka, M., Wieczorowska-Tobis, K. (2020) Pain in people with advanced dementia: The opinions of Kazakh medical students. *J. Pain Res.* **13**, 3307–3314.

Viderman, D., Tapinova, K., Dossov, M., Seitenov, S., Abdildin, Y. (2023) Virtual reality for pain management: An umbrella review. *Front. Med. (Lausanne)* **14(10)**, 1203670.

Viderman, D., Aubakirova, M., Salamat, A., Kaldybayev, D., Sadir, N., Tankacheyev, R., Abdildin, Y. (2024) The impact of gabapentinoids on pain-related outcomes after knee and hip surgery: A systematic review with meta-analysis of randomized controlled trials. *J. Clin. Med.* **13(14)**, 4205.

Vilai, P., Dhanachanvisith, N., Kongmalai, P. (2023) Efficacy of preemptive analgesia on tourniquet and postoperative pain relief in open carpal tunnel release: A prospective randomized control trial. *J. Hand Surg. Am.* **48(8)**, 828.e1–828.e7.

Wang, R. D., Zhu, J. Y., Zhu, Y., Ge, Y. S., Xu, G. L., Jia, W. D. (2020) Perioperative analgesia with parecoxib sodium improves postoperative pain and immune function in patients undergoing hepatectomy for hepatocellular carcinoma. *J. Eval. Clin. Pract.* **26(3)**, 992–1000.

Wang, W., Wang, Y., Lou, T., Ding, M., Li, J., Xiong, H., Yao, Z., Ma, Y., Chen, H., Liu, S. (2021) Celecoxib-loaded electrospun fibrous antiadhesion membranes reduce COX-2/PGE2 induced inflammation and epidural fibrosis in a rat failed back surgery syndrome model. *Neural. Plast.* **2021**, 6684176.

Wu, Q., Cui, X., Guan, L. C., Zhang, C., Liu, J., Ford, N. C., He, S., Chen, X., Cao, X., Zang, L., Guan, Y. (2023) Chronic pain after spine surgery: Insights into pathogenesis, new treatment, and preventive therapy. *J. Orthop. Translat.* **42**, 147–159.

Zeng, A. M., Nami, N. F., Wu, C. L., Murphy, J. D. (2016) The analgesic efficacy of nonsteroidal anti-inflammatory agents (NSAIDs) in patients undergoing cesarean deliveries: A meta-analysis. *Reg. Anesth. Pain Med.* **41(6)**, 763–772.

Zhaksylyk, A., Abdildin, Y., Sultangazin, S., Zhumakanova, A., Viderman, D. (2024) The impact of ketamine on pain-related outcomes after thoracotomy: A systematic review with meta-analysis of randomized controlled trials. *Front. Med. (Lausanne)* **11**, 1394219.

Zufferey, P., Chaux, R., Lachaud, P., Capdevila, X., Lanoiselée, J., Ollier, E. (2024) Dose-response relationships of intravenous and perineural dexamethasone as adjuvants to peripheral nerve blocks: A systematic review and model-based network meta-analysis. *Br. J. Anaesth.* **132(5)**, 1122–1132.