Advances in Biological Regulation 97 (2025) 101102

Impact Factor : 2.7
Q2

Contents lists available at ScienceDirect

Advances in Biological Regulation

journal homepage: www.elsevier.com/locate/jbior

In-depth review of breast cancer and inflammation pre-and post-treatment strategies with conventional and novel Steroid agents

Panneerselvam Theivendren [a,*], Punitha Narayanasamy [b], Kumarappan Chidamabaram [c], Sangeetha Menon [d], Josephin Arockia Dhivya Antony Sahayaraj [e], Natarajan Kiruthiga [f], Balaji Pandiyan [g]

[a] Department of Pharmaceutical Chemistry & Analysis, School of Pharmaceutical Sciences, Vels Institute of Science, Technology & Advanced Studies, Pallavaram, Chennai, Tamil Nadu, 600117, India
[b] Department of Physics, St. Joseph's College of Engineering, OMR, Chennai, Tamil Nadu, 600119, India
[c] Department of Pharmacology, College of Pharmacy, King Khalid University, Abha, 61421, Asir Province, Saudi Arabia
[d] Department of Life Sciences, Kristu Jayanti College Autonomous, Bengaluru, Karnataka, 560077, India
[e] Department of Biomedical Engineering, Vels Institute of Science, Technology & Advanced Studies, Pallavaram, Chennai, Tamil Nadu, 600117, India
[f] Department of Pharmaceutical Chemistry, KMCH College of Pharmacy, Kalappatti Road, Coimbatore, Tamil Nadu, 641048, India
[g] Department of Pharmacology, School of Pharmaceutical Sciences, Vels Institute of Science, Technology & Advanced Studies, Pallavaram, Chennai, Tamil Nadu, 600117, India

ARTICLE INFO

Handling Editor: Dr. L. Cocco

Keywords:
Breast cancer
Inflammation
Steroid agents
Corticosteroids
Cancerous tissue
Anti-inflammatory treatment
Effective treatment

ABSTRACT

Breast cancer leads to many women's cancer deaths worldwide and inflammation is essential for tumors to develop, advance and spread within the body. High levels of ongoing inflammation within the tumor help cancer cells multiply, encourage blood vessel formation and allow the cancer cells to evade detection by the immune system, so it is a target of choice for many cancer treatments. The relationship between breast cancer and inflammation is explored, stressing how important both early and late stages are, with both traditional and novel steroid options. For many years, corticosteroids and other conventional steroids have been used to help relieve side effects of treatment and boost the well-being of patients. Even so, steroids only working in certain patients and side effects have pushed scientists to discover new type of steroid derivatives that are better and safer. Targeted inflammation control and altered immune response in tumors by these new steroids could make therapy more successful. This review looks at current evidence from different types of studies to determine steroids' role in treating breast cancer-related inflammation. It also reviews options for using steroids together with chemotherapy, radiotherapy and immunotherapy, focusing on achieving the best anti-inflammatory results while keeping the inability to respond to treatment low. The study also looks at potential future progress in developing steroids, personalized medicine and therapies guided by biomarkers that could greatly improve how breast cancer is managed. Knowing how steroids affect tumors as well as inflammation is necessary for creating good treatment plans that improve breast cancer patients' chances of survival and lower their risk of disease recurrence.

* Corresponding author. School of Pharmaceutical Sciences, Vels Institute of Science, Technology & Advanced Studies, Pallavaram, Chennai, Tamil Nadu, 600117, India.
E-mail address: tpsphc@gmail.com (P. Theivendren).

https://doi.org/10.1016/j.jbior.2025.101102
Received 27 June 2025; Received in revised form 8 July 2025; Accepted 11 July 2025
Available online 15 July 2025

1. Introduction

Women everywhere, more than any other group, tend to develop breast cancer and die from it. Although we have achieved great results in early diagnosis and care, breast cancer remains a big problem for public health because it is so varied and difficult to treat. Inflammation is among the significant contributors to breast cancer and it is now considered an important sign of cancer. When there is ongoing inflammation in a tumor, it helps cause cancer by encouraging mutations, extra cell growth, new blood vessel growth and spreading of the cancer to new parts of the body. It is also key in altering the immune cells around the tumor, helping the cancer avoid and resist therapy. There is more than one way that inflammation may be linked to breast cancer. Tumor growth and survival are aided by the influence of inflammatory cells and their related mediators, including cytokines, chemokines and prostaglandins. Mediators such as NF-κB, STAT3 and COX-2 are turned on by these factors and these signaling pathways control how cells move through the cell cycle, stop apoptosis and form new blood vessels. Also, people with obesity and metabolic syndrome, who typically have systemic inflammation, have a greater risk of breast cancer and worse outcomes, pointing to the importance of both kinds of inflammation (Cuthrell and Tzenios, 2023; Kim et al., 2025; Wilkinson and Gathani, 2022).

In light of inflammation's major role in breast cancer, stopping inflammation has become an important approach to treating the disease. Doctors and scientists have widely employed steroid agents, mainly corticosteroids, because of their strong ability to control inflammation and alter the immune system's function. In the past, these drugs were chosen mainly to keep side effects from treatment like swelling, allergies and nausea at a minimum and to help patients feel better overall. Also, corticosteroids work with chemotherapy and radiotherapy by controlling inflammation and lessening swelling related to the tumor. Yet, there are some problems associated with traditional steroids. When corticosteroids must be used for a long time, they can reduce immunity, lead to blood sugar problems, cause brittle bones and make the drugs less effective in future use. Also, because steroids can both slow down and speed up cancer progression in different conditions, a clearer strategy is needed for their use (Danforth, 2021; Wu et al., 2022; Xiong et al., 2025) Fig. 1.

Interest in inventing new steroid agents and steroid treatment methods that control inflammation and the immune system with higher safety is increasing recently. The new steroid compounds target certain steroid receptors or signaling systems to manage inflammation associated with cancer (tumor-promoting inflammation). Researchers are studying drugs called selective glucocorticoid receptor modulators (SGRMs) and mineralocorticoid receptor antagonists to see how they can help with inflammation and limit the risks linked to steroid drugs. Furthermore, doctors often use steroid agents alongside chemotherapy, radiotherapy, hormonal therapy and immunotherapy for a greater overall benefit. Such combination treatments could increase the success of treating tumors by decreasing inflammation's impact, better delivering medicines and restoring the immune system's activity. Work is being done to add steroids into personal treatment plans, based on signs of inflammation and whether the patient has a steroid response, so the results can be better with less risk (Ingawale and Mandlik, 2020; Sheng et al., 2023; Stone et al., 2021).

It examines how inflammation relates to breast cancer, with a special look at the roles of various steroid-based medications used before and after treatment. It brings together current research on how steroids act in breast cancer cell function, reviews their clinical application and looks at new directions for using steroids to treat inflammation. The authors discuss the difficulties and opportunities of adding steroids to different therapies for breast cancer, so that patients benefit with better outcomes and quality of life. This work aims to achieve various results.

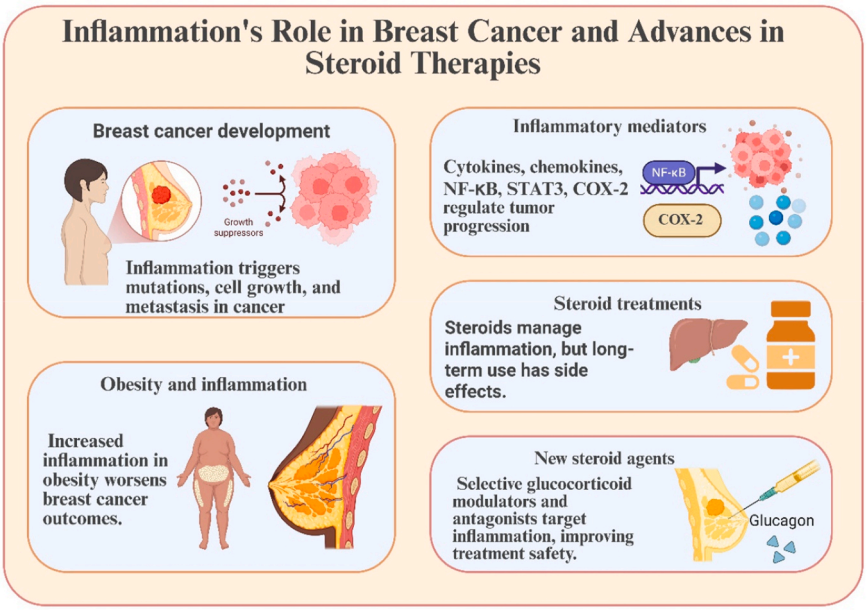

Fig. 1. This figure highlights inflammation's critical role in breast cancer progression and resistance, and illustrates how conventional and novel steroid therapies aim to reduce inflammation with improved safety and efficacy.

Our aim in this review is to assess the role of inflammation in breast cancer and to review conventional and novel steroid therapies for use before and after treatment. This paper sets out to review the scientific evidence, describe obstacles in steroid treatments and propose ideas for progress in managing breast cancer with steroids Table 1.

2. The role of inflammation in breast cancer development and progression

More and more, inflammation is seen as a key factor in both the onset and progress of breast cancer. Usually considered to defend the body from infections and injuries, science now knows that ongoing inflammation in cancer biology can end up encouraging cancer cells to grow. Long-lasting inflammation around and within the breast further increases the chances of cancer appearing, growing and spreading. The inflammation that supports tumor growth includes the action of many immune cells, different cytokines, chemokines and multiple signaling pathways. Uncontrolled inflammation often leads to gene and epigenetic changes in breast epithelial cells. If the body is regularly exposed to reactive oxygen species, nitrogen species and those cytokines, DNA damage may arise and disturb healthy cellular functions. Stress on genetic material may cause the activation of certain cancer-promoting genes or a reduction in tumor-suppressing genes which boosts the risk of cancer. Besides, when the body responds to inflammation, certain proteins, including NF-κB, STAT3 and COX-2, can become abnormally activated in breast tumor cells. As a result, these pathways control the expression of genes that are important for cell division, survival, forming new blood vessels and spreading tumors, allowing them to be important triggers of inflammation linked to cancer (Danforth, 2021; Zhao et al., 2021).

The area surrounding the tumor greatly contributes to persistent inflammation and supports breast cancer's spread. Microtumors have cancer cells along with stromal cells, immune cells, elements from the extracellular matrix and many soluble factors. Among TME cells, TAMs, MDSCs, neutrophils and regulatory T cells are found, secreting cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6) and transforming growth factor-beta (TGF-β). Cytokines help to create an environment where the immune system is less likely to notice cancer cells which aids the cells' spread to other sites in the body. It is often seen that TAMs look like M2 macrophages which help with building new blood vessels in the tumor and models, but not with fighting pathogens that would stop them. Alongside tissue inflammation, having obesity or metabolic syndrome throughout the body has been related to more cases of breast cancer and worse outcomes. Adipose tissue from obese people emits pro-inflammatory adipokines and cytokines that may change the breast tissue's daily balance and cause a mild, ongoing inflammation. Inflammation throughout the body causes the tumor to grow and may affect breast cancer by influence over estrogen signaling (Danforth, 2021; Terceiro et al., 2021) Fig. 2.

How inflammation affects breast cancer greatly affects how it is treated clinically. It shows that inflammation is an important sign of disease and can be targeted by therapy. Research has looked at anti-inflammatory drugs, NSAIDs and corticosteroids, to see if they can prevent breast cancer and make treatments more successful. Still, because inflammatory signaling is so involved and treating inflammation can affect the body's defenses, doctors should be cautious when using cancer therapies targeting inflammation. All in all, inflammation helps trigger and speed up breast cancer, playing a role in many aspects of tumor development such as genetic mutation, avoidance of the immune system and invasion of organs distant from the breast. The way cancer cells interact with inflammation inside the tumor shows why combined treatments that control inflammation but preserve the immune system are needed. On-going studies are breaking down how inflammation plays a role, allowing researchers to develop first-of-a-kind anti-inflammatory approaches that may aid in the prevention and treatment of breast cancer (Danforth, 2021; Xiong et al., 2025) Table 2.

Table 1
Summary of key topics on breast cancer inflammation and steroid therapies, highlighting main points, challenges, and future directions for improving diagnosis, treatment, and personalized care approaches.

Topic	Key Points	Challenges	Future Directions
Breast Cancer Prevalence	Women are most affected worldwide; leading cause of cancer death	Highly varied and difficult to treat	Early diagnosis and personalized care continue to improve
Role of Inflammation	Drives mutations, cell proliferation, angiogenesis, metastasis	Complex interactions with immune cells	Targeting inflammation to improve treatment outcomes
Inflammatory Mediators	Cytokines, chemokines, prostaglandins; activate NF-κB, STAT3, COX-2	Pathways promote tumor growth and therapy resistance	Developing drugs targeting these signaling pathways
Systemic Inflammation	Obesity and metabolic syndrome increase breast cancer risk	Systemic inflammation complicates management	Addressing systemic inflammation as part of treatment
Conventional Steroid Use	Corticosteroids reduce treatment side effects, control tumor-related inflammation	Long-term use causes immunosuppression, metabolic issues	Optimizing dosing to balance benefits and risks
Steroid Limitations	Can both inhibit and promote cancer progression	Risk of reduced efficacy and adverse effects	Need for clearer steroid use guidelines
Novel Steroid Agents	Selective glucocorticoid receptor modulators (SGRMs), mineralocorticoid receptor antagonists	Limited clinical data; safety profiles under investigation	Targeted inflammation control with fewer side effects
Combination Therapies	Steroids used with chemo, radio, hormonal, immunotherapy	Complex interactions, risk of immune suppression	Integration into personalized multimodal treatment plans
Personalized Steroid Therapy	Tailoring steroids based on inflammation biomarkers and patient response	Identifying predictive markers and treatment algorithms	Precision medicine approaches to improve outcomes
Review Objectives	Assess inflammation's role; evaluate steroid therapies pre- and post-treatment	Overcoming obstacles in steroid treatment strategies	Propose advances to optimize steroid use in breast cancer care

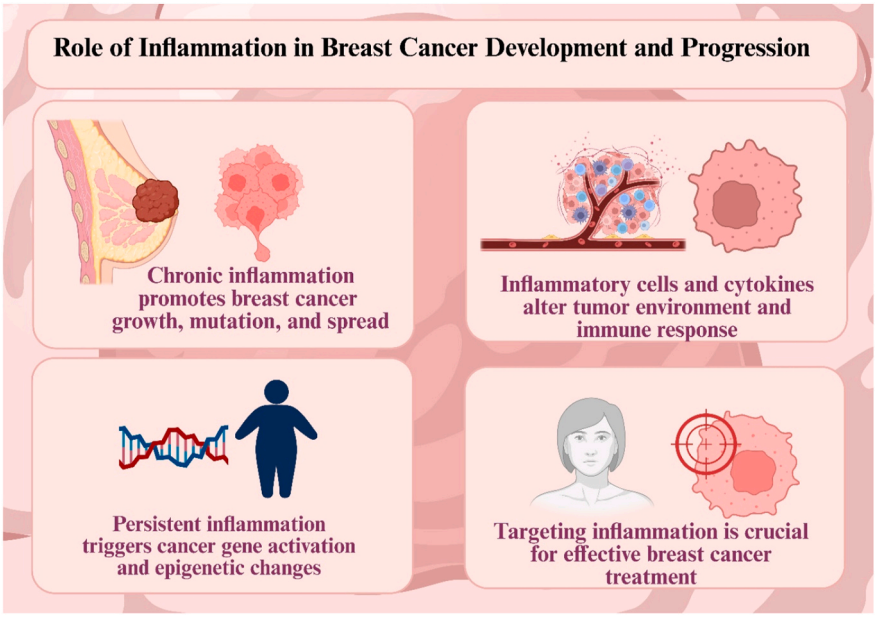

Fig. 2. This figure illustrates how chronic inflammation drives breast cancer development through tumor growth, gene changes, and immune modulation, emphasizing the importance of targeting inflammation for effective treatment strategies.

3. Conventional Steroid agents in breast cancer management

In managing breast cancer, corticosteroids are important because they control inflammation, weaken the immune system and reduce swelling. Many glucocorticoid-like drugs are commonly added to breast cancer therapy to make chemotherapy, radiotherapy and targeted treatments easier for patients to endure. Antihistamines can relieve swelling, allergic problems, nausea brought on by medication, brain swelling and sensitivity reactions. While they are used a lot in clinical settings to relieve symptoms, corticosteroids also play a role in controlling the biology and responses of breast tumors to therapy. Corticosteroids cause their effects by connecting to GRs found within cells and moving these receptors to the nucleus to adjust gene activity. Because of this genomic action, pro-inflammatory proteins such as IL-1, TNF-α and interferons are not manufactured and production of the anti-inflammatory protein

Table 2
Overview of inflammation's multifaceted role in breast cancer, detailing key mechanisms, cellular players, and clinical implications, alongside therapeutic strategies and future research priorities for optimized steroid and anti-inflammatory treatments.

Aspect	Description	Key Players	Clinical Implications
Inflammation in Cancer	Chronic inflammation promotes breast cancer initiation, growth, and metastasis	Immune cells, cytokines, chemokines	Targeting inflammation is critical in breast cancer therapy
Genetic & Epigenetic Effects	Reactive oxygen/nitrogen species and cytokines cause DNA damage, gene activation/suppression	NF-κB, STAT3, COX-2	Abnormal activation of these pathways drives tumor progression
Tumor Microenvironment (TME)	Comprises cancer cells, stromal and immune cells, extracellular matrix, soluble factors	TAMs (M2-like), MDSCs, neutrophils, Tregs	TME fosters immune evasion and tumor spread
Cytokine Influence	TNF-α, IL-6, TGF-β secreted by immune cells suppress immune response and promote metastasis	TNF-α, IL-6, TGF-β	Creates immunosuppressive environment aiding cancer escape
Obesity & Systemic Inflammation	Adipose tissue secretes pro-inflammatory factors causing systemic inflammation affecting breast tissue	Adipokines, cytokines	Links obesity/metabolic syndrome to higher breast cancer risk
Inflammation & Estrogen Signaling	Systemic inflammation can alter estrogen pathways, impacting tumor growth	Estrogen receptors, inflammatory mediators	Suggests interaction between hormonal and inflammatory pathways
Therapeutic Considerations	Anti-inflammatory drugs (NSAIDs, corticosteroids) show promise but require cautious use	NSAIDs, corticosteroids	Need to balance inflammation control with immune system preservation
Treatment Strategy	Combining inflammation control with immune preservation to enhance cancer therapy outcomes	Immunomodulation, targeted therapy	Future therapies aim at precise modulation of inflammation
Research Directions	Ongoing studies dissect inflammation's role to develop novel anti-inflammatory treatments	Molecular signaling, immune checkpoints	Potential for prevention and improved breast cancer treatment
Review Objectives	Assess inflammation's role; evaluate steroid therapies pre- and post-treatment	Overcoming obstacles in steroid treatment strategies	Propose advances to optimize steroid use in breast cancer care

lipocortin-1 is increased. Thanks to their anti-inflammatory effect, corticosteroids remove tissue swelling and leakage of fluids from the blood into cancer juggles, that are often more severe with cancer treatment. The anti-inflammatory benefits reduce pain, swelling and fatigue for people being treated for breast cancer using aggressive therapy (Mehta et al., 2022; Placha and Jampilek, 2021).

Often during chemotherapy, corticosteroids are given first to help prevent or reduce hypersensitivity reactions from agents such as paclitaxel and docetaxel. When taken with appropriate antiemetic medicines, they reduce chemotherapy-linked nausea and vomiting. Corticosteroids also seem to make chemotherapy more effective when they reduce the inflammatory effects that can lead to drug resistance. Steroids are also commonly used in radiotherapy to treat inflammation and fluid accumulation caused by radiation in the brain or lungs because such swelling can become very dangerous. Yet, applying basic steroids to breast cancer comes with major problems. When people take corticosteroids for a long time or at large doses, it can cause complications such as a lowered immune system, a higher chance of infection, high blood sugar, high blood pressure, weak bones and thin muscles. Therefore, a lot of attention must be given to the amount of medicine used and watching patients. In addition, there is new evidence that corticosteroids may sometimes have opposite results in breast cancer cells. Corticosteroids decrease inflammation, yet in specific circumstances, they also make cancer cells stress-resistant, faster reproducing and able to move to different parts of the body by triggering GR-mediated signals. As a result, it is important to balance any use of steroids.

Patients who are on steroids for a long time can start to show resistance to steroids. When GRA is changed, receptors mutate or signals downstream become disrupted, steroid treatment faces resistance and makes management more challenging. They can also disrupt the effectiveness of immune checkpoint inhibitors by lowering the immune system's ability to fight the tumor, making the success of emergent immunotherapies in breast cancer more difficult(Almuhizi et al., 2022; Lansinger et al., 2021) Fig. 3.

Because of these problems, corticosteroids are still critical in treating breast cancer, mainly for handling symptoms and to support during systemic therapy. Doctors keep using these medications, so scientists are working to fine-tune the doses, control negative effects and better explore their connections with cancer. The investigation of ways to use medicines that spare steroids and have improved safety is a current focus. To finish, conventional steroids contribute different benefits in breast cancer care by relieving inflammation and improving the comfort and success of main treatments. A good balance between expected benefits and risks should be considered before using them. Advances in steroid science and medicine that fit patients' needs may improve results for those fighting breast cancer (Marazzi et al., 2020; Mitre-Aguilar et al., 2022) Table 3.

4. Novel Steroid agents and selective receptor modulators

With the introduction of new steroid agents and specific receptor modulators, disease management through therapy for inflammation-related conditions such as breast cancer, has improved. Although traditional corticosteroids are effective in controlling inflammation and the immune response, they may cause several troublesome side effects that limit the time they can be used. As a result of the harmful effects that steroids may have on metabolism, bones and immunity, scientists are working to achieve treatments that manage inflammation without leading to other troublesome effects. Developing novel steroid drugs and selective receptor modulators allows for targeting receptors and pathways related to steroid hormones more steadily which should boost both safety and stronger effectiveness. The main purpose of selective receptor modulators is to target the GR and MR receptors on a tissue and situation

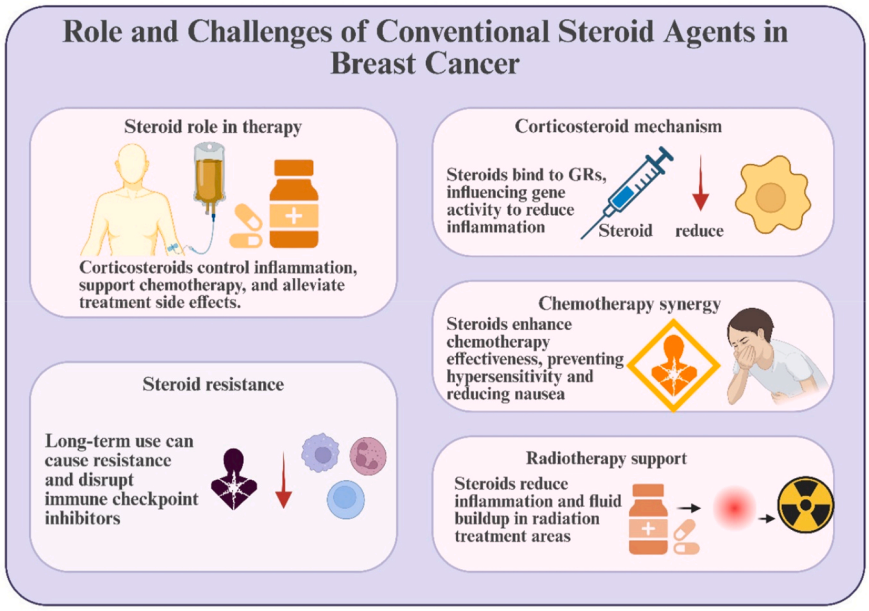

Fig. 3. This figure summarizes the role of conventional steroids in breast cancer care, highlighting their benefits in reducing inflammation and enhancing therapy, as well as potential side effects and resistance mechanisms.

Table 3
Summary of corticosteroid roles in breast cancer management, outlining mechanisms, therapeutic benefits, associated risks, and future directions aimed at optimizing safety and efficacy in combination treatments.

Aspect	Details	Benefits	Challenges/Risks
Role of Corticosteroids	Control inflammation, immune suppression, reduce swelling	Reduce pain, swelling, fatigue; improve treatment tolerance	Immune suppression; infection risk
Mechanism of Action	Bind to glucocorticoid receptors (GR), modulate gene expression	Decrease pro-inflammatory proteins (IL-1, TNF-α, interferons); increase lipocortin-1	Complex genomic effects, dual role in cancer biology
Use with Chemotherapy	Prevent hypersensitivity to agents like paclitaxel, docetaxel	Reduce allergic reactions, nausea, vomiting	Potential development of steroid resistance
Use with Radiotherapy	Treat inflammation and fluid buildup, especially in brain and lungs	Reduce radiation-induced edema and tissue damage	Long-term side effects
Anti-inflammatory Effects	Reduce tissue swelling, vascular leakage	Improve symptom control during aggressive therapy	Risk of masking infections and delayed healing
Steroid Resistance	Altered GRs and signaling pathways cause reduced effectiveness	Understanding resistance mechanisms may improve treatment	Makes long-term management challenging
Impact on Immunotherapy	May reduce immune system's ability to fight cancer	Manage immune-related side effects	May impair effectiveness of immune checkpoint inhibitors
Long-term Side Effects	Hyperglycemia, hypertension, osteoporosis, muscle wasting	Careful monitoring and dose adjustment essential	Limits prolonged corticosteroid use
Dual Effects on Tumors	Can suppress inflammation but sometimes promote cancer cell survival and metastasis	Potential to influence tumor biology	Necessitates careful risk-benefit assessment
Future Directions	Focus on dose optimization, steroid-sparing agents, and personalized approaches	Enhance safety and efficacy	Requires further research and clinical validation

basis. Instead of stimulating every receptor, SRMs can either stimulate or reduce activity based on the cell they reach which causes fewer side effects. SGRMs, for example, have been made so that they help with anti-inflammatory and immunosuppressive effects, but reduce the risk of raising blood sugar and suppressing the adrenal glands. They manage this by modifying receptor shapes, drawing specific partner proteins to join them and affecting genes differently than classical glucocorticoids (Agarwal et al., 2021; Foster, 2021).

Breast cancer tumors often use inflammation in their surroundings to help grow, spread and withstand treatment. Using new kinds of steroids to selectively change receptor activity in the tumor setting may break the connection between inflammation and tumor growth without affecting the rest of the immune system. Various preclinical experiments now indicate that SRMs can suppress inflammatory cytokines and chemokines, inhibit the spread of new blood vessels and influence how immune cells are present in tumors. They may help improve the treatment success of chemotherapy, radiotherapy and immunotherapy by handling the problems associated with inflammation. Mineralocorticoid receptor antagonists are being studied for their effects on both inflammation and fibrosis in cancer too. The start of the MR process has been proven to encourage changes in tissues such as scarring which might help cancer advance and spread. Blocking some of the MR might lower the harmful changes found in tumor microenvironments. Additionally, non-

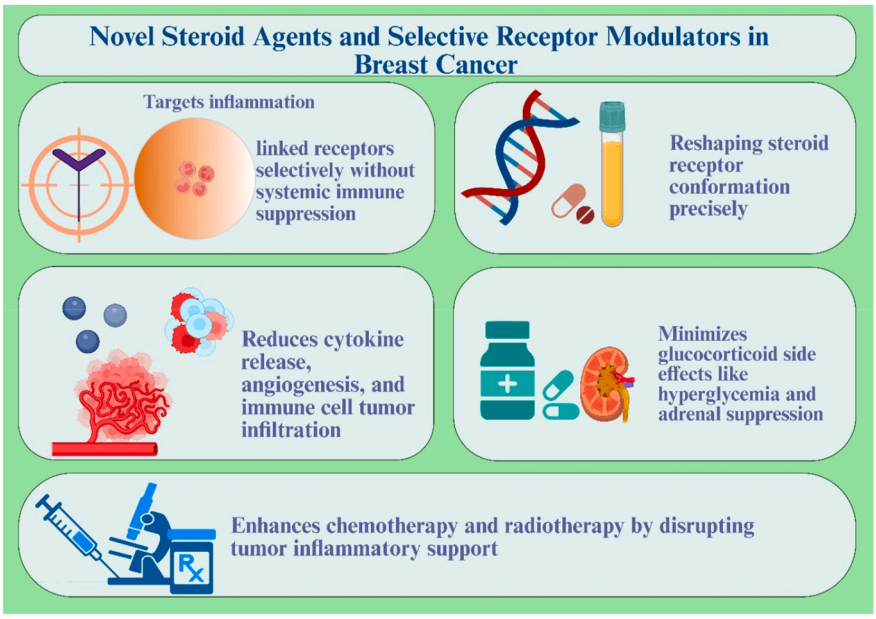

Fig. 4. This figure outlines novel steroid agents and selective receptor modulators, highlighting their targeted anti-inflammatory actions, reduced side effects, fibrosis prevention, and the role of precision medicine in breast cancer therapy.

steroidal selective receptor modulators have improved features such as being able to be taken by mouth, showing fewer side effects and having improved kinetic profiles (Danforth, 2021; Xiong et al., 2025) Fig. 4.

Still, a number of challenges remain before novel steroid agents and selective receptor modulators can be used in healthcare. The fact that there is complexity in receptor mechanisms means that medicines must be carefully assessed for specificity, efficacy and safety. At present, clinical trials are being carried out to check these parameters in different inflammatory and cancerous conditions, including breast cancer. Scientists are also working on identifying biomarkers that can help doctors choose which patients will have the best results from SRM therapies which fits with the main ideas of precision medicine. Sharper outcomes could also be seen when combining novel steroid agents with classic therapy approaches. When used together, SRMs might help reduce unwanted immune symptoms without affecting the immune system's ability to fight cancer. Also, using unique steroids in before or after surgery phases may benefit the treatment and cut down on later recurrence by targeting inflammation (Clarisse et al., 2022; Myrbäck et al., 2020).

All told, novel steroid-like agents and selective receptor modulators are showing great promise in anti-inflammatory and cancer treatments. As they can modulate tissue-specific receptors and cause fewer side effects such agents improve on traditional corticosteroids and allow new ways to fight inflammation caused by breast cancer. Going forward, we need more studies and clinical experiments to better apply them and add them to the overall approach to treating breast cancer. Table 4.

5. Pre-treatment anti-inflammatory strategies using steroids

Using steroids before starting conventional treatments such as chemotherapy, radiotherapy or immunotherapy has become important for improving breast cancer therapy. Inflammation within the tumor site greatly contributes to cancer becoming tougher to treat, more likely to come back and to additional toxic effects from treatment. Early administration of steroids that lower inflammation can help treatment work better, cause fewer problems and offer a more positive outcome for patients. Because corticosteroids are very potent against inflammation and the body's immune response, they are usually the first treatment given in cancer therapy. Prior to chemotherapy, they are helpful by reducing the chance of allergic reactions that commonly occur with taxanes and platinum drugs. Administering steroids in advance helps control fever, chills, rash and anaphylaxis, so patients can use the standard doses of their medications without having to lower them (Goldman et al., 2022; Petrelli et al., 2020).

In addition to reducing allergic reactions, steroids used before therapy help neutralize the overactive inflammation in the tumor microenvironment that is commonly caused by cytotoxic agents. When steroids inhibit a series of cytokines like interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α) and cyclooxygenase-2 (COX-2), they reduce tissue swelling, increased leakage from blood vessels and the entry of some immune cells into tumors that hinder treatment. This effect changes the environment so that following therapies can function more successfully. During the pre-treatment phase, choosing how much, when and what type of steroid agents is necessary to obtain maximum good effects and few side effects. Usually, patients given between low and moderate doses of dexamethasone or prednisone receive the drug a short time before the chemotherapy infusion. Still, steroid treatment should be adjusted based on the patient's health, the form of tumor and related medical conditions. Continuous or large amounts of steroids in the body can decrease the immune response, making controlling cancer over the long term difficult (Ma et al., 2020; Zhao et al., 2021).

New types of steroid compounds and selective glucocorticoid receptor modulators (SGRMs) are being evaluated for use prior to treatment. They give us the power to control inflammation more directly, at lower risk of using our immune system. Experiments outside of clinical trials have shown that SGRMs can be selective in switching off certain inflammatory genes in tumors without disrupting the immune monitoring of the body when used with medicines such as immune checkpoint inhibitors. This targeted

Table 4
Overview of novel steroid agents and selective receptor modulators (SRMs) in breast cancer therapy, highlighting their mechanisms, clinical benefits, challenges, and future precision medicine strategies.

Aspect	Description	Benefits	Challenges/Considerations
Limitations of Traditional Steroids	Effective for inflammation but cause metabolic, bone, immune side effects	Established anti-inflammatory effects	Side effects limit long-term use
Novel Steroid Agents	Designed to target steroid hormone receptors more selectively	Improved safety and efficacy	Complexity in receptor targeting
Selective Receptor Modulators (SRMs)	Tissue- and context-specific modulation of GR and MR receptors	Reduced side effects by selective activation/inhibition	Need for specificity and safety validation
Selective Glucocorticoid Receptor Modulators (SGRMs)	Retain anti-inflammatory/immunosuppressive effects with fewer metabolic effects	Lower risk of blood sugar elevation, adrenal suppression	Clinical trials ongoing
Tumor Microenvironment Effects	SRMs suppress inflammatory cytokines, inhibit angiogenesis, modulate immune cells in tumors	Potentially improves chemo, radio, immunotherapy outcomes	Preclinical evidence; clinical validation needed
Mineralocorticoid Receptor (MR) Antagonists	Target fibrosis and tissue remodeling linked to tumor progression	May reduce tumor-supporting fibrosis and inflammation	Mechanisms still under study
Non-Steroidal SRMs	Oral bioavailability, fewer side effects, better pharmacokinetics	Convenient dosing, improved patient compliance	Early-stage development
Clinical Challenges	Complex receptor signaling requires careful drug assessment	Ensures specificity and safety	Need for biomarker-driven patient selection
Precision Medicine Approach	Biomarkers to predict patient response to SRM therapy	Personalized, targeted treatments	Identification and validation of biomarkers ongoing
Combination Therapies	SRMs combined with conventional treatments to reduce immune side effects	Enhanced efficacy and safety	Optimizing dosing and timing

blocking may increase the safety and performance of early inflammation prevention treatments. Treatment with steroids before therapy is also useful in patients with cancer in the central nervous system to control brain swelling and related nerve inflammation. Corticosteroids given a few hours before surgery or radiotherapy will reduce intracranial pressure and improve both neurological function and comfort for patients. Steroids are important for making patients fitter and more ready for tough medical procedures.

Results from clinical trials show that giving steroids before chemotherapy reduces hospitalizations, helps patients tolerate chemotherapy better and leads to a better quality of life. Even so, optimizing these strategies is not easy, as it is difficult to study how steroids, cells from the immune system and cancer cells interact in every type of breast cancer. Further research is required to select biomarkers able to identify patients reacting positively to steroid pre-treatment and to set up the same protocols around the world (Hu et al., 2022; Pang et al., 2022) Fig. 5.

Overall, using anti-inflammatory steroids as a pre-treatment measure is very important in breast cancer care. Because steroids reduce inflammation and its effects, they help patients respond safely and effectively to cancer treatments. Selective steroid drugs are expected to give medical professionals a chance to target inflammation in each person, achieving better results with fewer unwanted side effects Table 5.

6. Post-treatment Steroid use for managing side effects and recurrence

In people who have gone through breast cancer treatment, steroid use helps lessen side effects and avoids cancer returning. After receiving surgery, chemotherapy, radiotherapy or immunotherapy for primary cancer, many patients experience complications related to inflammation that can slow the healing process, make life less comfortable and occasionally result in cancer returning. Corticosteroids are normally used after cancer treatment because they have strong anti-inflammatory, immunosuppressive and anti-edematous properties that protect against a range of undesired outcomes and curb lingering inflammation that can lead to tumor recurrence. When the body experiences inflammation caused by radiation, post-treatment steroids are commonly recommended. Radiotherapy works to hit cancer cells, but it frequently results in a local reaction characterized by erythema, edema, fibrosis and pain. They lessen inflammatory problems by stopping pro-inflammatory cytokines and steadying the cell walls. This, in turn, decreases discomfort and allows tissue to recover. With radiation pneumonitis or fibrosis which can seriously affect lung function, steroids are usually given to reduce swelling and prevent permanent harm. Inflammation and edema in the area after surgery, mainly for mastectomy or lymph node procedures, is best countered with steroids, to aid in healing and manage lymphedema (Andreu et al., 2022; Tommasi et al., 2022).

Post-treatment use of steroids is becoming more important now that immune-related side effects (irAEs) related to immunotherapy are frequently seen in breast cancer. While immune checkpoint inhibitors use the body's immune system to treat cancer, they can lead to immune-type side effects in the skin, liver, stomach and endocrine glands. For these side effects, your doctor may give you corticosteroids for control, making it easier to continue immunotherapy if you can or giving you symptomatic relief if you have to hold the treatment. To maintain the best effectiveness, steroids' effects are regulated so that anti-tumor immunity is supported and serious complications are prevented. In addition to taming side effects, taking steroids after breast cancer treatment may affect the chance of tumor recurrence by reducing inflammation around the original cancer. Cancer survivors with ongoing inflammation stand a higher

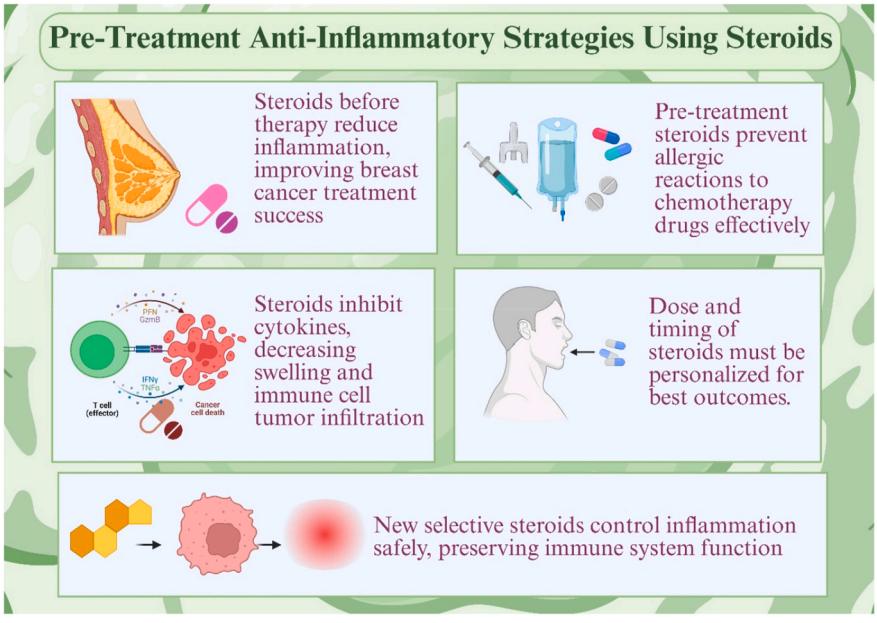

Fig. 5. This figure illustrates pre-treatment anti-inflammatory strategies using steroids in breast cancer, emphasizing reduced inflammation, allergic reaction prevention, cytokine inhibition, and the importance of personalized dosing and selective steroid development.

Table 5
Summary of pre-treatment steroid use in breast cancer, covering their role in inflammation control, prevention of allergic reactions, immune impact, clinical outcomes, and future directions toward personalized therapies.

Aspect	Description	Benefits	Challenges/Considerations
Importance of Pre-Treatment	Steroids given before chemo, radio, or immunotherapy to improve outcomes	Improves treatment tolerance and efficacy	Requires careful timing and dosing
Role in Tumor Inflammation	Reduces inflammation in tumor microenvironment by inhibiting cytokines like IL-6, TNF-α, COX-2	Lowers swelling, vessel leakage, immune cell infiltration	Complex tumor-immune-steroid interactions
Prevention of Allergic Reactions	Minimizes hypersensitivity to taxanes, platinum drugs before chemotherapy	Reduces fever, rash, anaphylaxis	Steroid choice and dose must be individualized
Common Steroids Used	Dexamethasone and prednisone at low to moderate doses	Effective and widely accepted	Adjust based on patient health and tumor type
Immune System Impact	Long or high-dose steroids can suppress immunity	Balances inflammation control with immune preservation	Avoid over-immunosuppression to maintain cancer control
Novel Steroid Compounds	Selective glucocorticoid receptor modulators (SGRMs)	Target inflammation with less immune suppression	Still in experimental and clinical trial phases
Use in CNS Cancers	Controls brain swelling and nerve inflammation before surgery/radiotherapy	Reduces intracranial pressure, improves neurological status	Careful management needed for CNS toxicity
Clinical Outcomes	Steroids before chemotherapy reduce hospitalizations and improve quality of life	Better chemo tolerance and fewer complications	Optimization across cancer subtypes is challenging
Biomarker Research	Need for markers to predict which patients benefit from steroid pre-treatment	Enables personalized steroid use	Biomarker identification is ongoing
Future Perspectives	Selective steroids promise targeted inflammation control with fewer side effects	Enhanced safety and effectiveness	Requires more research and global protocol standardization

risk of their tumors recovering, spreading to other organs and not responding to treatment. The theory is that suppressing inflammation with steroids could help to prevent another attack. Even so, there is controversy because steroids lower the body's defenses against cancer cells that remain after treatment. This means that when and how much of the medication is given is important for steroids to help calm inflammation but not weaken the body's resistance to cancer (Correia et al., 2021; Tommasi et al., 2022) Fig. 6.

Steroids can help, but using them for too long or at high doses after treatment leads to greater risks such as easier infection, high blood sugar, weak bones, weight loss from muscle and mood changes. For this reason, people using steroids must be carefully watched and the drugs should only be used when necessary. New SGRMs and targeted steroid agents may help reduce these dangers by providing anti-inflammatory results that affect few areas of the body. In short, steroids given after treatment are vital for fighting side effects of inflammation and may affect breast cancer recurrence. Taking corticosteroids is important for radiation damage, post-surgery tissues and immune effects, improving both recovery and daily life for patients. Nevertheless, more research is needed to better understand how their effect on cancer recurrence can be improved. With better ideas in selective steroid therapy, post-treatment steroids may be both safer and more effective, resulting in better outcomes for breast cancer survivors (Pofi et al., 2023; Sosale et al.,

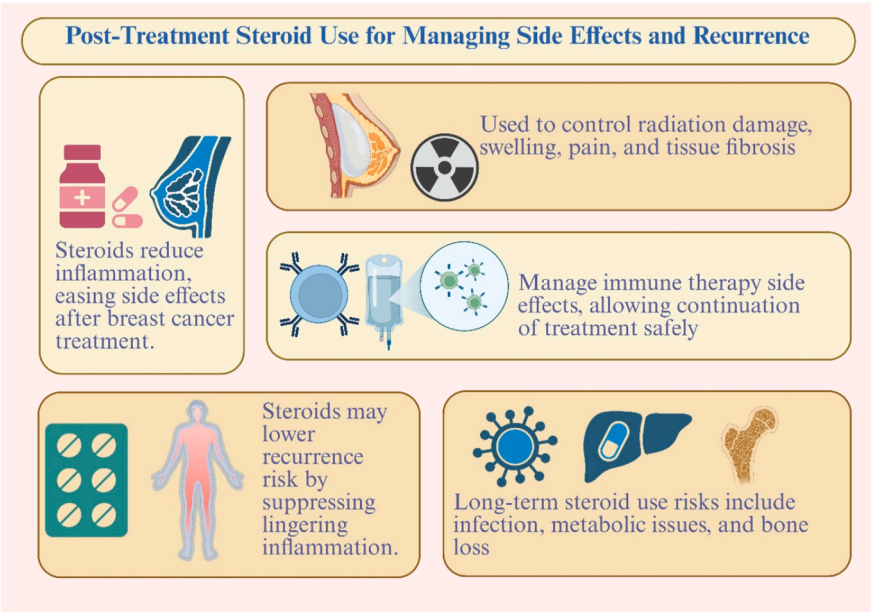

Fig. 6. This figure presents the role of post-treatment steroid use in managing breast cancer side effects and recurrence, highlighting benefits in reducing inflammation and fibrosis, while addressing long-term risks like infection and bone loss.

2021) Table 6.

7. Combination therapies: steroids with chemotherapy, radiotherapy, and immunotherapy

Steroids, along with chemotherapy, radiotherapy and immunotherapy, are now important for the full treatment of breast cancer. Most of these therapies involve corticosteroids to improve how well they treat patients, protect against unwanted side effects and create better results. Because they help reduce inflammation and guide the immune response, steroids become useful when added to other types of cancer therapy. Corticosteroids are given in chemotherapy to limit sensitivity reactions, stomach upset and nausea. Some types of chemotherapy, in particular taxanes and platinum compounds, may cause serious allergic or inflammatory reactions that interfere with a patient's ability to stick to the treatment or take the required dose. The use of steroids gradually cuts down these reactions by calming the body's immune defenses and lowering cytokine levels. Using corticosteroids may reduce inflammation caused by chemotherapy in the tumor's surroundings, an effect linked to resistance to chemotherapy treatment. When steroids control inflammatory reactions, they might help cancer treatments work more effectively against cancer cells (Goodman et al., 2023; Trayes and Cokenakes, 2021)

Because radiotherapy is used frequently in breast cancer treatment, it brings on significant inflammation that results in acute skin reactions like dermatitis and edema, plus long-term effects including fibrosis and tissue death. Steroids given during or following radiation therapy can lessen these inflammation problems and make it easier for tissues to recover. Corticosteroids are the most effective drugs for treating radiation pneumonitis, a potentially serious side effect of chest irradiation. Because they combat inflammation, they stop organs from progressing towards fibrosis. Using steroids in the right way during radiotherapy allows patients to handle stronger or broader treatments, improving their chances against cancer. Steroids and ICIs, when used together, create a complicated interaction process. Because ICIs like those to PD-1, PD-L1 and CTLA-4 stimulate the immune system, this can trigger immune-related adverse events (irAEs) that can damage several organs. The main treatment for serious irAEs is corticosteroids; they reduce swelling in the body and prevent organs from being damaged. Most importantly, studies have shown that, when given in low doses for a short time, steroids normally do not block the anti-tumor effects of ICIs. It is very important to balance cancer control with safety for the patients (Hannoodee and Nasuruddin, 2024; Silverberg et al., 2023).

In addition to controlling side effects, new research points out that steroids could alter how tumors behave and respond to these types of treatment. Resistance to chemotherapy, radiotherapy and immunotherapy is in part due to persistent inflammation within the tumor's surroundings. They might help beat the resistance by altering the activity of NF-κB and STAT3, important parts of the inflammatory signaling process. Despite these benefits, steroid overuse could reduce positive immune effects against tumors or give an edge to tumor cells, due to the way these drugs use glucocorticoid receptors. So, making sure the dose is right and choosing the correct patient is extremely important. SGRMs and newly developed medicines from the steroid group are promising for use alongside other drugs. They are created to lower the chance of inflammation and side effects and, at the same time, may improve the outcomes of combined cancer therapy. Studies are going on to find out if these medicines are safe and effective when used together (Mortezaee and Najafi, 2021; Peng et al., 2023) Fig. 7.

Adding steroids to chemotherapy, radiotherapy and immunotherapy is a versatile approach to treating breast cancer. Using steroids in chemotherapy reduces common harmful side effects, increases how tolerable the treatment is and may even help overcome forms of resistance, leading to better outcomes for patients. Advancements in how steroids are used and the development of new steroids will help perfect the combination therapies for breast cancer patients (David et al., 2022; Yu et al., 2022) Table 7.

Table 6
Overview of post-treatment steroid use in breast cancer, detailing therapeutic purposes, benefits in managing side effects and recurrence, associated risks, and the potential of novel agents for improved outcomes.

Aspect	Description	Benefits	Challenges/Considerations
Purpose of Post-Treatment Use	Manage inflammation-related side effects and reduce risk of cancer recurrence	Controls lingering inflammation, reduces complications	Balancing inflammation control with immune function
Radiation-Induced Inflammation	Steroids treat erythema, edema, fibrosis, pain following radiotherapy	Reduces tissue damage and pain	Risk of long-term side effects
Radiation Pneumonitis & Fibrosis	Steroids reduce lung inflammation and prevent permanent damage	Preserve lung function	Requires careful dosing and monitoring
Post-Surgical Inflammation	Manage swelling and lymphedema after mastectomy or lymph node surgery	Supports tissue healing and reduces discomfort	Timing and dose critical
Immune-Related Adverse Events	Steroids control irAEs caused by immunotherapy (skin, liver, GI, endocrine issues)	Enables continuation or safer pause of immunotherapy	Avoid dampening anti-tumor immunity
Effect on Cancer Recurrence	Steroids may reduce inflammation that promotes tumor regrowth	Potentially lower recurrence risk	Controversial due to immunosuppressive effects
Side Effects of Steroids	Long-term/high-dose use risks include infections, hyperglycemia, osteoporosis, muscle loss	Monitoring mitigates risks	Limits prolonged use
Novel Steroid Agents	Selective glucocorticoid receptor modulators (SGRMs) offer targeted anti-inflammatory action	Fewer systemic side effects	Still under clinical investigation
Importance in Recovery	Steroids improve recovery and quality of life post-treatment	Manage inflammation across multiple treatment-related effects	Optimal protocols still needed
Research Needs	More studies required on steroid impact on recurrence and safer targeted therapies	Aim for improved patient outcomes	Need for personalized dosing and treatment strategies

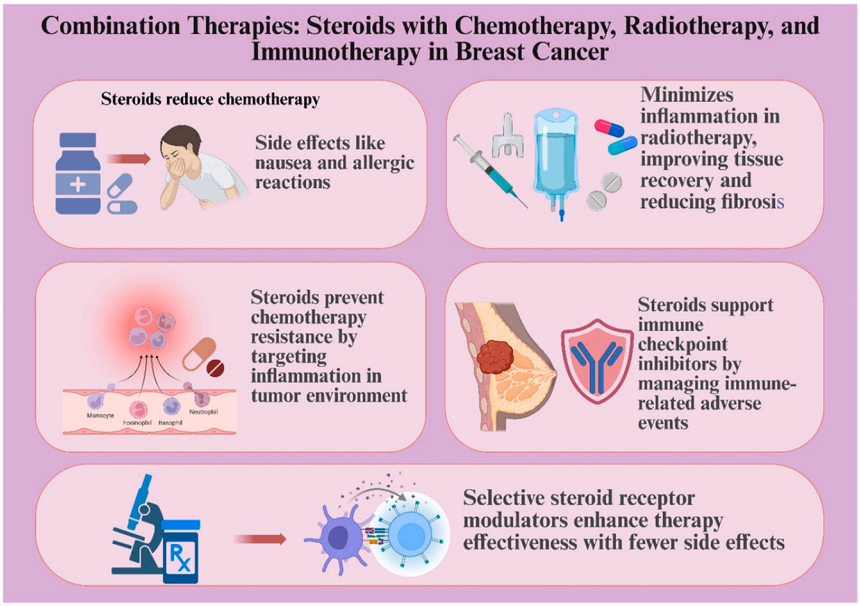

Fig. 7. This figure illustrates the integration of steroids with chemotherapy, radiotherapy, and immunotherapy in breast cancer care. It highlights how steroids mitigate inflammation, prevent side effects, and enhance treatment effectiveness while aiming to preserve immune function and minimize long-term risks.

8. Future perspectives and personalized Steroid therapy in breast cancer

The future of steroid therapy in breast cancer lies in the realm of personalized medicine, which seeks to tailor treatments to the unique genetic, molecular, and immunological profiles of individual patients. While conventional corticosteroids have long been used to manage inflammation and treatment-related side effects in breast cancer, their broad systemic effects and potential for adverse outcomes highlight the urgent need for more targeted and individualized approaches. Advances in molecular biology, genomics, and pharmacology are paving the way for personalized steroid therapies that maximize therapeutic benefits while minimizing risks. One promising future direction is the development of selective glucocorticoid receptor modulators (SGRMs) and other novel steroid agents designed to precisely modulate receptor activity in a tissue- and context-specific manner. Unlike traditional corticosteroids that activate glucocorticoid receptors (GRs) ubiquitously, these selective modulators can discriminate between beneficial anti-inflammatory actions and unwanted metabolic or immunosuppressive effects. This selectivity is achieved through altering receptor conformation, co-regulator recruitment, and gene transcription patterns, thereby enabling fine-tuned regulation of inflammatory pathways within the tumor microenvironment without broadly suppressing systemic immunity. Such agents hold the potential to improve outcomes in breast cancer by effectively controlling tumor-promoting inflammation while preserving the body's natural anti-cancer immune responses (Papalexis et al., 2024; Rajkhowa et al., 2024).

Personalized steroid therapy also involves integrating patient-specific biomarkers that predict steroid responsiveness, risk of side effects, and potential interactions with other treatments. Molecular profiling of tumors and immune cells can identify variations in glucocorticoid receptor expression, receptor isoforms, and downstream signaling components that influence steroid efficacy. For example, some breast cancer subtypes may be more susceptible to steroid-induced modulation of inflammatory pathways, while others might exhibit resistance or adverse reactions. Additionally, pharmacogenomic data on steroid metabolism and receptor polymorphisms can guide dose adjustments and choice of steroid agents, reducing the incidence of toxicity and improving tolerability. The integration of steroid therapy with other personalized treatment modalities represents another exciting frontier. Combining selective steroid modulators with targeted therapies, immunotherapies, or hormonal treatments offers opportunities to enhance synergy and overcome resistance mechanisms. For instance, steroids may be used to mitigate immune-related adverse events during checkpoint inhibitor therapy without compromising anti-tumor efficacy, provided their use is carefully personalized. Moreover, dynamic monitoring of inflammatory biomarkers during treatment can inform real-time adjustments in steroid dosing, optimizing therapeutic windows and reducing cumulative toxicity (Bhayana et al., 2023; Davoudi et al., 2023).

Technological innovations such as advanced imaging techniques and liquid biopsies will facilitate personalized steroid therapy by enabling non-invasive assessment of tumor inflammation, immune cell infiltration, and steroid receptor activity. These tools can help clinicians monitor treatment response and adjust steroid regimens accordingly, fostering adaptive and precision-guided care. Despite the promise, challenges remain in implementing personalized steroid therapy broadly. Comprehensive clinical trials are required to validate biomarkers, establish dosing algorithms, and evaluate long-term outcomes of novel steroid agents in diverse patient populations. Additionally, the complexity of steroid receptor signaling and its crosstalk with other molecular pathways necessitates continued research to unravel context-dependent effects in breast cancer (Abusara et al., 2025; Bao et al., 2024) Fig. 8.

Table 7
Summary of the role of steroids in combination with chemotherapy, radiotherapy, and immunotherapy for breast cancer, highlighting benefits, challenges, and future research directions for optimizing treatment efficacy and safety.

Aspect	Description	Benefits	Challenges/Considerations
Role of Steroids in Combination	Used alongside chemo, radio, immunotherapy to enhance treatment efficacy and reduce side effects	Improves patient tolerance and treatment success	Requires balancing dose and timing
Steroids with Chemotherapy	Reduce hypersensitivity, nausea, inflammatory reactions from agents like taxanes and platinum	Enables full dosing, reduces allergic reactions	Risk of steroid resistance, immune suppression
Steroids with Radiotherapy	Manage acute skin inflammation, edema, radiation pneumonitis, and long-term fibrosis	Eases symptoms, prevents tissue damage	Need careful dosing to avoid adverse effects
Steroids with Immune Checkpoint Inhibitors (ICIs)	Control immune-related adverse events (irAEs) triggered by ICIs (PD-1, PD-L1, CTLA-4)	Allows continuation of immunotherapy, reduces organ damage	Potential risk of dampening anti-tumor immune response
Inflammation & Treatment Resistance	Persistent inflammation drives resistance to chemo, radio, immunotherapy	Steroids may modulate NF-κB and STAT3 to overcome resistance	Overuse may promote tumor survival or reduce immunity
Importance of Dose & Patient Selection	Precise dosing and patient choice crucial for maximizing benefits	Optimizes outcomes, minimizes risks	Lack of universal protocols
Novel Steroid Agents & SGRMs	Designed to reduce inflammation with fewer side effects	Potentially safer and more effective with combination therapy	Still under clinical evaluation
Steroids Enhance Treatment Tolerance	Improve chemotherapy tolerance by reducing side effects	Better patient adherence and outcomes	Monitoring needed to avoid side effects
Synergy in Multimodal Therapy	Steroids complement different cancer therapies for improved overall efficacy	Allows use of stronger or broader treatment regimens	Complex interactions require thorough clinical oversight
Future Research Directions	Ongoing studies on steroid safety, efficacy, and optimal use in combination therapies	Aim to personalize and refine breast cancer treatments	Requires biomarker development and large-scale trials

In conclusion, future perspectives in steroid therapy for breast cancer emphasize personalization through selective receptor modulation, biomarker-guided treatment, and integration with multimodal therapies. By harnessing advances in molecular medicine and technology, personalized steroid therapy promises to enhance efficacy, minimize adverse effects, and improve quality of life for breast cancer patients. Continued innovation and clinical validation will be essential to realize this vision and transform steroid use into a precision oncology tool (Bai et al., 2025; Khan et al., 2025) Table 8.

9. Discussion

Because breast cancer is linked to inflammation, effective use of anti-inflammatory methods can help before and after a patient receives treatment. Since inflammation causes cancer as well as many side effects from treatments, it is important to manage it

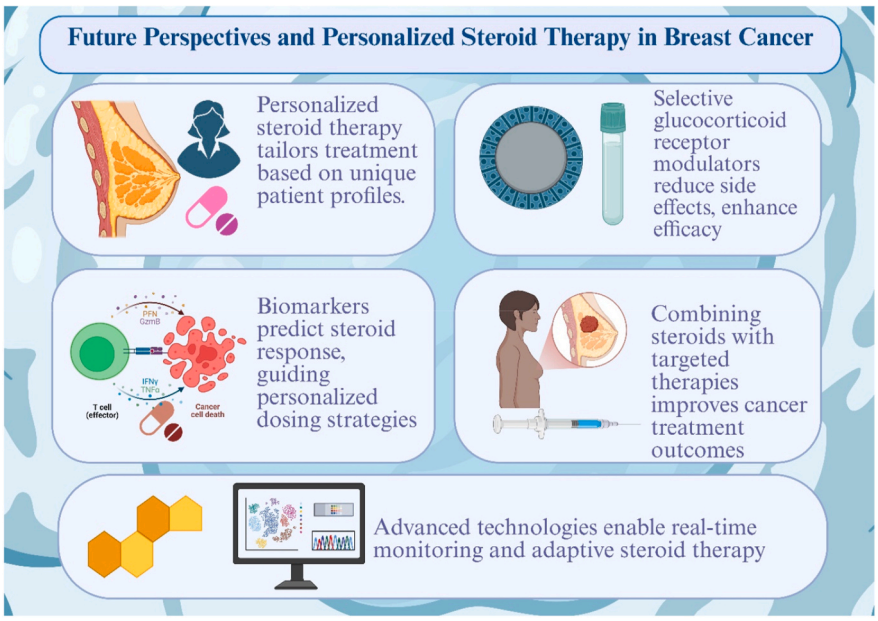

Fig. 8. This infographic outlines key challenges and future directions for AI in nutraceuticals, emphasizing the need for data standardization, regulatory adaptation, explainable AI, and the role of emerging technologies like blockchain and IoT in enhancing AI integration.

Table 8
Overview of personalized steroid therapy in breast cancer, detailing approaches to precision medicine, selective modulators, biomarker use, combination strategies, and challenges in clinical implementation and future development.

Aspect	Description	Benefits	Challenges/Considerations
Personalized Medicine Approach	Tailoring steroid therapy based on genetic, molecular, and immune profiles	Maximizes benefit, minimizes side effects	Requires detailed patient profiling
Selective Glucocorticoid Receptor Modulators (SGRMs)	Target GRs with tissue- and context-specific actions	Reduce metabolic and immunosuppressive side effects	Complex receptor dynamics
Mechanism of Selectivity	Alter receptor shape, co-regulator recruitment, gene transcription	Fine-tuned inflammation control without systemic suppression	Understanding molecular pathways needed
Biomarker Integration	Use tumor and immune biomarkers to predict steroid response and toxicity	Personalized dosing and agent selection	Identification and validation ongoing
Pharmacogenomics	Genetic variations in steroid metabolism and receptor polymorphisms guide therapy	Reduce toxicity, improve tolerability	Requires extensive genomic data
Combination with Other Therapies	Integration with targeted, hormonal, and immune therapies	Synergistic effects, overcoming resistance	Optimizing timing and dose
Management of Immune-Related Adverse Events (irAEs)	Steroids used cautiously to control irAEs during immunotherapy without blocking anti-tumor effects	Maintain efficacy and patient safety	Balancing immune suppression
Monitoring Technologies	Advanced imaging and liquid biopsies enable real-time assessment	Adaptive, precision-guided steroid therapy	Access and standardization challenges
Clinical Trials & Validation	Need for large trials to confirm biomarkers, dosing, safety, and long-term outcomes	Evidence-based protocols for diverse populations	High costs and complexity
Future Vision	Personalized steroid therapy as a precision oncology tool	Enhanced efficacy, fewer side effects, better quality of life	Ongoing innovation and research essential

carefully and thoroughly. For years, corticosteroids have been used regularly in breast cancer care by controlling hard-to-manage inflammation and making chemotherapy and radiotherapy more comfortable for patients. Still, since they weaken the immune system and have side effects, many people can't use them long term. Thanks to new steroid agents and selective receptor modulators, it is now possible to fight inflammation precisely and with less toxicity. They may be used to target inflammation more selectively within the tumor and have the ability to fit in with other treatment options and boost how much they achieve. Taking steroids before starting the treatment reduces inflammation, makes the tumor environment friendlier and prevents strong reactions of hypersensitivity. Steroids given after treatment fight residual inflammation and other problems related to the immune system, helping patients heal. But the task of preventing overactive inflammation while keeping the immune system operating correctly is quite hard. To make steroid therapy safer and more effective, a personal plan is important, based on the patient's unique needs and key blood results. More studies are needed to uncover the mechanisms behind steroids in breast cancer, perfect how much medicine to give and bring in new drugs into combined treatments. Altogether, mixing standard and new steroids with planned treatments is very important for boosting results and reducing problems due to inflammation.

10. Conclusion

Breast cancer develops, spreads and responds to therapy mainly because of inflammation. focus on inflammation is important for developing treatments. Managing the unpleasant side effects and making breast cancer treatment easier for patients has involved using conventional steroids. Even so, their wide impact on the immune system and the related hazards reduce the time patients can safely use them, making it important to find better treatments. Novel steroid drugs and selective receptor modulators offer a new approach because they target inflammation well and have less toxic effect on the body. They may be effective at handling the microenvironment surrounding the tumor and interacting positively with popular cancer control methods such as chemotherapy, radiotherapy and immunotherapy. By giving steroids early and late, we get better control of the inflammation in the body, lower some uncomfortable symptoms and reduce the risk that the cancer could come back. Using personalized steroid therapy based on biomarkers and the patient's needs is becoming important for maintaining good inflammatory control without causing serious damage to the immune system. Because of this, coming research should focus on how steroids work at the cellular level, optimizing the dosing schedules and adding new agents to better cancer treatment routines. The combination of existing and experimental steroid strategies before and after treatment offers a helpful way to improve breast cancer therapy, reduce side effects and improve patients' quality of life. This method is important for kindling precision medicine for breast cancer, as it explores the link between cancer inflammation and tumor biology.

CRediT authorship contribution statement

Panneerselvam Theivendren: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Punitha Narayanasamy:** Writing – review & editing, Visualization, Validation. **Kumarappan Chidamabaram:** Writing – review & editing, Visualization, Validation. **Sangeetha Menon:** Writing – review & editing, Visualization, Validation. **Josephin Arockia Dhivya Antony Sahayaraj:** Writing – review & editing, Visualization, Validation. **Natarajan Kiruthiga:** Writing – review & editing, Visualization, Validation. **Balaji Pandiyan:** Writing – review & editing, Visualization, Validation.

Funding declaration

The authors declare that no funding was received for this study.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

References

Abusara, O.H., Agha, A.S.A., Bardaweel, S.K., 2025. Advancements and innovations in liquid biopsy through microfluidic technology for cancer diagnosis. Analyst 150 (9), 1711–1725.
Agarwal, R., Kolkhof, P., Bakris, G., Bauersachs, J., Haller, H., Wada, T., Zannad, F., 2021. Steroidal and non-steroidal mineralocorticoid receptor antagonists in cardiorenal medicine. Eur. Heart J. 42 (2), 152–161.
Almuhizi, F., De Las Vecillas Sanchez, L., Gilbert, L., Copaescu, A.M., Isabwe, G.A., 2022. Premedication protocols to prevent hypersensitivity reactions to chemotherapy: a literature review. Clin. Rev. Allergy Immunol. 62 (3), 534–547.
Andreu, Y., Soto-Rubio, A., Ramos-Campos, M., Escriche-Saura, A., Martínez, M., Gavilá, J., 2022. Impact of hormone therapy side effects on health-related quality of life, distress, and well-being of breast cancer survivors. Sci. Rep. 12 (1), 18673.
Bai, J., Gao, Y., Zhang, G., 2025. The treatment of breast cancer in the era of precision medicine. Cancer Biol. Med. 22 (4), 322–347.
Bao, Y., Zhang, D., Guo, H., Ma, W., 2024. Beyond blood: advancing the frontiers of liquid biopsy in oncology and personalized medicine. Cancer Sci. 115 (4), 1060–1072.
Bhayana, S., Zhao, Y., Merchant, M., Cummins, T., Dougherty, J.A., Kamigaki, Y., Pathmasiri, W., McRitchie, S., Mariani, L.H., Sumner, S., 2023. Multiomics analysis of plasma proteomics and metabolomics of steroid resistance in childhood nephrotic syndrome using a "patient-specific" approach. Kidney Int. Rep. 8 (6), 1239–1254.
Clarisse, D., Deng, L., De Bosscher, K., Lother, A., 2022. Approaches towards tissue-selective pharmacology of the mineralocorticoid receptor. Br. J. Pharmacol. 179 (13), 3235–3249.
Correia, A.S., Gärtner, F., Vale, N., 2021. Drug combination and repurposing for cancer therapy: the example of breast cancer. Heliyon 7 (1), e05948.
Cuthrell, K.M., Tzenios, N., 2023. Breast cancer: updated and deep insights. Int. Res. J. Oncol. 6 (1), 104–118.
Danforth, D.N., 2021. The role of chronic inflammation in the development of breast cancer. Cancers 13 (15), 3918.
David, S., Tan, J., Siva, S., Karroum, L., Savas, P., Loi, S., 2022. Combining radiotherapy and immunotherapy in metastatic breast cancer: current status and future directions. Biomedicines 10 (4), 821.
Davoudi, F., Moradi, A., Becker, T.M., Lock, J.G., Abbey, B., Fontanarosa, D., Haworth, A., Clements, J., Ecker, R.C., Batra, J., 2023. Genomic and phenotypic biomarkers for precision medicine guidance in advanced prostate cancer. Curr. Treat. Options Oncol. 24 (10), 1451–1471.
Foster, P.A., 2021. Steroid sulphatase and its inhibitors: past, present, and future. Molecules 26 (10), 2852.
Goldman, M., Lucke-Wold, B., Martinez-Sosa, M., Katz, J., Mehkri, Y., Valisno, J., Quintin, S., 2022. Steroid utility, immunotherapy, and brain tumor management: an update on conflicting therapies. Explor Target Antitumor Ther. 3 (5), 659.
Goodman, R.S., Johnson, D.B., Balko, J.M., 2023. Corticosteroids and cancer immunotherapy. Clin. Cancer Res. 29 (14), 2580–2587.
Hannoodee, S., Nasuruddin, D.N., 2024. Acute Inflammatory Response, StatPearls [Internet]. StatPearls Publishing.
Hu, X., Pang, J., Chen, C., Jiang, D., Shen, C., Chai, X., Yang, L., Zhang, X., Xu, L., Cui, S., 2022. Discovery of novel non-steroidal selective glucocorticoid receptor modulators by structure-and IGN-based virtual screening, structural optimization, and biological evaluation. Eur. J. Med. Chem. 237, 114382.
Ingawale, D.K., Mandlik, S.K., 2020. New insights into the novel anti-inflammatory mode of action of glucocorticoids. Immunopharmacol. Immunotoxicol. 42 (2), 59–73.
Khan, Y., Rizvi, S., Raza, A., Khan, A., Hussain, S., Khan, N.U., Alshammari, S.O., Alshammari, Q.A., Alshammari, A., Ellakwa, D.E.-S., 2025. Tailored therapies for triple-negative breast cancer: current landscape and future perceptions. N. Schmied. Arch. Pharmacol. 1–26.
Kim, J., Harper, A., McCormack, V., Sung, H., Houssami, N., Morgan, E., Mutebi, M., Garvey, G., Soerjomataram, I., Fidler-Benaoudia, M.M., 2025. Global patterns and trends in breast cancer incidence and mortality across 185 countries. Nat. Med. 1–9.
Lansinger, O.M., Biedermann, S., He, Z., Colevas, A.D., 2021. Do steroids matter? A retrospective review of premedication for taxane chemotherapy and hypersensitivity reactions. J. Clin. Oncol. 39 (32), 3583–3590.
Ma, S., Song, W., Xu, Y., Si, X., Zhang, D., Lv, S., Yang, C., Ma, L., Tang, Z., Chen, X., 2020. Neutralizing tumor-promoting inflammation with polypeptide-dexamethasone conjugate for microenvironment modulation and colorectal cancer therapy. Biomaterials 232, 119676.
Marazzi, F., Orlandi, A., Manfrida, S., Masiello, V., Di Leone, A., Massaccesi, M., Moschella, F., Franceschini, G., Bria, E., Gambacorta, M.A., 2020. Diagnosis and treatment of bone metastases in breast cancer: radiotherapy, local approach and systemic therapy in a guide for clinicians. Cancers 12 (9), 2390.
Mehta, J., Rolta, R., Mehta, B.B., Kaushik, N., Choi, E.H., Kaushik, N.K., 2022. Role of dexamethasone and methylprednisolone corticosteroids in coronavirus disease 2019 hospitalized patients: a review. Front. Microbiol. 13, 813358.
Mitre-Aguilar, I.B., Moreno-Mitre, D., Melendez-Zajgla, J., Maldonado, V., Jacobo-Herrera, N.J., Ramirez-Gonzalez, V., Mendoza-Almanza, G., 2022. The role of glucocorticoids in breast cancer therapy. Curr. Oncol. 30 (1), 298–314.
Mortezaee, K., Najafi, M., 2021. Immune system in cancer radiotherapy: resistance mechanisms and therapy perspectives. Crit. Rev. Oncol.-Hematol. 157, 103180.
Myrbäck, T.H., Prothon, S., Edman, K., Leander, J., Hashemi, M., Dearman, M., Edenro, G., Svanberg, P., Andersson, E.-M., Almquist, J., 2020. Effects of a selective glucocorticoid receptor modulator (AZD9567) versus prednisolone in healthy volunteers: two phase 1, single-blind, randomised controlled trials. Lancet Rheumatol. 2 (1), e31–e41.
Pang, J.-p., Hu, X.-p., Wang, Y.-x., Liao, J.-n., Chai, X., Wang, X.-w., Shen, C., Wang, J.-j., Zhang, L.-l., Wang, X.-y., 2022. Discovery of a novel nonsteroidal selective glucocorticoid receptor modulator by virtual screening and bioassays. Acta Pharmacol. Sin. 43 (9), 2429–2438.
Papalexis, P., Georgakopoulou, V.E., Drossos, P.V., Thymara, E., Nonni, A., Lazaris, A.C., Zografos, G.C., Spandidos, D.A., Kavantzas, N., Thomopoulou, G.E., 2024. Precision medicine in breast cancer. Mol. Clin. Oncol. 21 (5), 78.
Peng, J., Yin, X., Yun, W., Meng, X., Huang, Z., 2023. Radiotherapy-induced tumor physical microenvironment remodeling to overcome immunotherapy resistance. Cancer Lett. 559, 216108.
Petrelli, F., Signorelli, D., Ghidini, M., Ghidini, A., Pizzutilo, E.G., Ruggieri, L., Cabiddu, M., Borgonovo, K., Dognini, G., Brighenti, M., 2020. Association of steroids use with survival in patients treated with immune checkpoint inhibitors: a systematic review and meta-analysis. Cancers 12 (3), 546.
Placha, D., Jampilek, J., 2021. Chronic inflammatory diseases, anti-inflammatory agents and their delivery nanosystems. Pharmaceutics 13 (1), 64.

Pofi, R., Caratti, G., Ray, D.W., Tomlinson, J.W., 2023. Treating the side effects of exogenous glucocorticoids; can we separate the good from the bad? Endocr. Rev. 44 (6), 975–1011.
Rajkhowa, S., Zeenat, S., Agarwal, M., Zaheen, A., Zaki, M.E., Sinha, S., 2024. From genes to recovery: precision medicine and its influence on multidrug resistant breast cancer. Breast Cancer Genetics, Immunology, and Immunotherapy: an Interdisciplinary Approach. Springer, pp. 187–235.
Sheng, M., Chen, Y., Li, H., Zhang, Y., Zhang, Z., 2023. The application of corticosteroids for pathological scar prevention and treatment: current review and update. Burns Trauma 11, tkad009.
Silverberg, J., Jackson, J.M., Kirsner, R.S., Adiri, R., Friedman, G., Gao, X.-H., Billings, S.D., Kerkmann, U., 2023. Narrative review of the pathogenesis of stasis dermatitis: an inflammatory skin manifestation of venous hypertension. Dermatol. Therapy 13 (4), 935–950.
Sosale, A., Sosale, B., Kesavadev, J., Chawla, M., Reddy, S., Saboo, B., Misra, A., 2021. Steroid use during COVID-19 infection and hyperglycemia–what a physician should know. Diabetes Metabol. Syndr.: Clin. Res. Rev. 15 (4), 102167.
Stone, S., Malanga, G.A., Capella, T., 2021. Corticosteroids: review of the history, the effectiveness, and adverse effects in the treatment of joint pain. Pain Physician 24 (S1), S233.
Terceiro, L.E., Edechi, C.A., Ikeogu, N.M., Nickel, B.E., Hombach-Klonisch, S., Sharif, T., Leygue, E., Myal, Y., 2021. The breast tumor microenvironment: a key player in metastatic spread. Cancers 13 (19), 4798.
Tommasi, C., Balsano, R., Corianò, M., Pellegrino, B., Saba, G., Bardanzellu, F., Denaro, N., Ramundo, M., Toma, I., Fusaro, A., 2022. Long-term effects of breast cancer therapy and care: calm after the storm? J. Clin. Med. 11 (23), 7239.
Trayes, K.P., Cokenakes, S.E., 2021. Breast cancer treatment. Am. Fam. Physician 104 (2), 171–178.
Wilkinson, L., Gathani, T., 2022. Understanding breast cancer as a global health concern. Br. J. Radiol. 95 (1130), 20211033.
Wu, B., Sodji, Q.H., Oyelere, A.K., 2022. Inflammation, fibrosis and cancer: mechanisms, therapeutic options and challenges. Cancers 14 (3), 552.
Xiong, X., Zheng, L.-W., Ding, Y., Chen, Y.-F., Cai, Y.-W., Wang, L.-P., Huang, L., Liu, C.-C., Shao, Z.-M., Yu, K.-D., 2025. Breast cancer: pathogenesis and treatments. Signal Transduct. Targeted Ther. 10 (1), 49.
Yu, S., Wang, Y., He, P., Shao, B., Liu, F., Xiang, Z., Yang, T., Zeng, Y., He, T., Ma, J., 2022. Effective combinations of immunotherapy and radiotherapy for cancer treatment. Front. Oncol. 12, 809304.
Zhao, H., Wu, L., Yan, G., Chen, Y., Zhou, M., Wu, Y., Li, Y., 2021. Inflammation and tumor progression: signaling pathways and targeted intervention. Signal Transduct. Targeted Ther. 6 (1), 263.