Review

The Mammary Gland: Anatomy, Histology, Pathology and Post-Surgery Physiotherapy Management

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Abstract:
The mammary gland is a highly specialized organ dedicated to milk production, composed of glandular, connective, and adipose tissues. It undergoes dynamic structural changes throughout life, influenced by hormonal cycles essential for reproduction and lactation. Despite its vital physiological role, the mammary gland is susceptible to pathological conditions, most notably breast carcinoma, which remains the leading cause of cancer-related deaths among women. This article provides an overview of the anatomy, histology, pathology, and physiotherapy rehabilitation strategies related to the mammary gland. A literature review was conducted drawing from peer-reviewed articles, textbooks, and guidelines to examine mammary gland anatomy, histology, breast carcinoma, and physiotherapy approaches following surgery. The lymphatic system, particularly the axillary lymph nodes, plays a crucial role in immune defense and serves as the primary route for metastatic spread in breast cancer, making it a key diagnostic and prognostic marker. Breast carcinoma can be benign, non-invasive malignant, or invasive malignant. Invasive carcinomas, including ductal and lobular carcinoma, are the most aggressive and frequently metastasize through lymphatic pathways. Post-surgical physiotherapy plays a vital role in managing complications like lymphedema, improving upper limb mobility, and supporting psychological well-being. Rehabilitation involves methods like manual lymphatic drainage, compression therapy, and advanced treatments, including low-level laser therapy, all aimed at accelerating recovery and enhancing quality of life. In Slovenia, physiotherapy protocols emphasize early patient education, gradual exercise progression, and lymphedema prevention. Personalized strategies integrating anatomical and pathological knowledge significantly enhance recovery outcomes and quality of life for breast cancer patients.

Keywords: Mammary gland anatomy and histology; Lymphatic system; Breast carcinoma; Breast cancer rehabilitation; Physiotherapy management.

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1. Introduction

The mammary gland is a sophisticated anatomical structure composed of glandular and adipose tissue, supported by fibrous connective tissue and positioned over the pectoral muscles of the chest wall. Extending from the second to seventh ribs, it is intricately designed with a network of blood vessels, lymphatic pathways, and sensory nerves, all of which contribute to its structural integrity, functional capacity, and physiological significance. A thorough understanding of its anatomy forms the basis for comprehending its role in health and disease. From a histological perspective, the mammary gland's complexity is further highlighted by its dynamic nature. Throughout an individual's life, hormonal cycles drive significant structural changes, enabling its essential role in reproduction and lactation. These adaptations not only support milk production but also underscore the gland's susceptibility to various pathological conditions.

An essential part of the mammary gland's physiology is its connection to the lymphatic system. This network, comprising lymphatic vessels, nodes, and major ducts, is critical for maintaining tissue–fluid balance, immune defense, and the clearance of interstitial fluid (Leong et al., 2022; Schuenke et al., 2010). Lymph nodes, such as the axillary nodes, play a pivotal role as filtering stations, cleansing lymph of pathogens and debris. Furthermore, the lymphatic system is a key pathway for the metastatic spread of cancer cells, with lymph nodes serving as important indicators of disease progression in breast cancer patients (Null et al., 2023; Natale et al., 2021).

One of the most significant pathological challenges associated with the mammary gland is breast cancer, which remains the most frequently diagnosed cancer worldwide. Accounting for 25% of all diagnosed cancers, it predominantly affects women, although men are also occasionally diagnosed with the disease (Tosello et al., 2018). Numerous risk factors, including gender, age, obesity, alcohol consumption, sedentary lifestyle, hormone exposure, radiation, family history, and genetic predisposition, contribute to its development (WHO, 2024). While the incidence of breast cancer has been rising, advances in early detection and treatment have significantly improved survival rates, particularly for localized stages of the disease (Katsura et al., 2022). Given the rising prevalence of breast cancer and the physical and emotional challenges faced by patients post-surgery, the role of targeted physiotherapy rehabilitation programs is increasingly recognized. These programs not only focus on restoring physical strength and upper limb function but also address psychological well-being, playing a critical role in enhancing overall recovery and quality of life after breast surgery.

2. Design of the Review

A literature review was conducted, selecting articles published between 1992 (Stark et al., 1992) and 2024 (WHO, 2024; Yang et al., 2024). The review focused on publications that described or examined the anatomical features and histological changes of the mammary gland, breast carcinoma and various physiotherapy approaches for managing patients after breast cancer surgery. Studies published in English and Slovene were included to ensure comprehensive coverage.

The reviewed literature encompassed a wide range of sources, including peer-reviewed scientific articles, academic textbooks, institutional guidelines, dissertations, and credible online resources. Peer-reviewed articles formed the backbone of the analysis, providing evidence-based insights into related topics, while systematic reviews and meta-analyses offered a synthesis of current research. Foundational knowledge was derived from academic textbooks and atlases, such as Schuenke et al. (2010) and Hayes & Nguyen (2014), which detailed anatomical and histological aspects of the mammary gland. Institutional guidelines, including those by the Slovenian Institute of Oncology (Onkološki inštitut, 2019), were integral in describing standardized rehabilitation approaches.

3. Breast Anatomy

The breast is a complex anatomical structure primarily composed of glandular and adipose tissue, supported by connective tissues and overlying the pectoral muscles of the chest wall (Dahmane and Cor, 2001). Its primary function is lactation, but the breast also holds

significant importance in physical, psychological, and sexual contexts (Bazira et al., 2022; Khan et al., 2025).

Women and men both have breasts (Torre et al., 2016). The breast of an adult woman typically weighs between 150 and 200 grams. It is located on the anterior chest wall, extending from the second or third rib to the sixth or seventh costal cartilage, medially reaching the sternal edge and laterally extending to the mid-axillary line. The breast is situated on the pectoralis major muscle, partially on the serratus anterior muscle, and on the external oblique abdominal muscle. The pectoralis minor muscle, located beneath the pectoralis major, serves as an important anatomical landmark for dividing the levels of lymph node drainage (Marolt Mušič et al., 2004).

The glandular tissue of the breast is covered by fascia, with its posterior surface being slightly concave to conform to the underlying muscles. (Marolt Mušič et al., 2004). Fatty tissue, known as adipose tissue, makes up the breasts (Aronson et al., 2000). The adipose tissue in the breasts is intertwined with a network of nerves, blood vessels, lymphatic vessels, lymph nodes, and also consists of fibrous connective tissue and ligaments (Thomsen & Tatman, 1998).

The sensory innervation of the breast arises from the anterior and lateral cutaneous branches of the intercostal nerves (fourth to sixth thoracic levels). This innervation not only mediates sensation but also plays a role in the hormonal regulation of lactation and sexual responsiveness (Rivard et al., 2023). The vascular supply of the breast is extensive, originating primarily from the internal thoracic artery, the lateral thoracic artery, and branches of the thoracoacromial artery. Venous drainage follows a similar pattern, emptying into the axillary and internal thoracic veins (Bazira et al., 2022).

The breast's lymphatic drainage is critical for immune defense and has significant implications for the metastatic spread of breast cancer. Approximately 75% of lymphatic drainage is directed toward the axillary lymph nodes, with additional pathways leading to the parasternal and supraclavicular nodes (Khan et al., 2025). Breasts vary in shape and size, with one breast often being slightly smaller than the other, and nipples also show a wide range of variation (Brayboy et al., 2017). The epidermis of the areola and nipple is highly pigmented and slightly wrinkled, while the skin of the nipple contains numerous apocrine and sebaceous glands, along with some small hairs. At the base of the nipple, milk ducts converge and expand into milk sinuses. These ducts facilitate the transport of milk to the nipples (Hassiotou & Geddes, 2013). Supporting these structures are fibrous tissues, including Cooper's ligaments, which help maintain the breast's shape and position (Khan et al., 2025). Female breasts typically contain more glandular tissue compared to male breasts (Stark et al., 1992). Female breasts are composed of 12–20 lobes, which are divided into smaller lobules (Tanis et al., 2001). These lobes and lobules are interconnected by 15–25 milk ducts. Female breasts are adapted to provide the best possible nourishment for babies and to offer sexual satisfaction to the woman. They are glandular organs that respond strongly to hormonal changes in the body (Jagannathan & Sharma, 2017).

4. Histology of the Breast Tissue

The breast (*glandula mammaria*) is a highly specialized organ composed of glandular, connective, and adipose tissues, with its histological architecture undergoing significant changes throughout life and uniquely designed for milk production. The glandular tissue has a tubular-alveolar structure which is organized into 15 to 20 lobes (*lobus mammae*). These alveoli are lined by a single layer of cuboidal epithelial cells, supported by contractile myoepithelial cells and a basement membrane, which aids in milk ejection. Lobes are arranged around the nipple (*papilla mammae*) where the epithelium transitions from simple cuboidal in the smaller ducts to stratified cuboidal and then to stratified squamous epithelium near the nipple (Baumgartner, 2018). Each lobe is drained by a lactiferous duct (*ductulus lactiferus*) and each lactiferous duct expands into a lactiferous sinus (*sinus lactiferus*), which narrows as it approaches the nipple and opens with a small pore (**Figure 1**). Within each lobe, smaller subdivisions called lobules (*lobulus mammae*) contain terminal duct lobular units (TDLUs), the primary structures responsible for milk production. (Takač, 1996; Hayes & Nguyen, 2014). Dense connective stroma surrounds the glandular structures, interspersed with adipose tissue that contributes to the breast's size and shape.

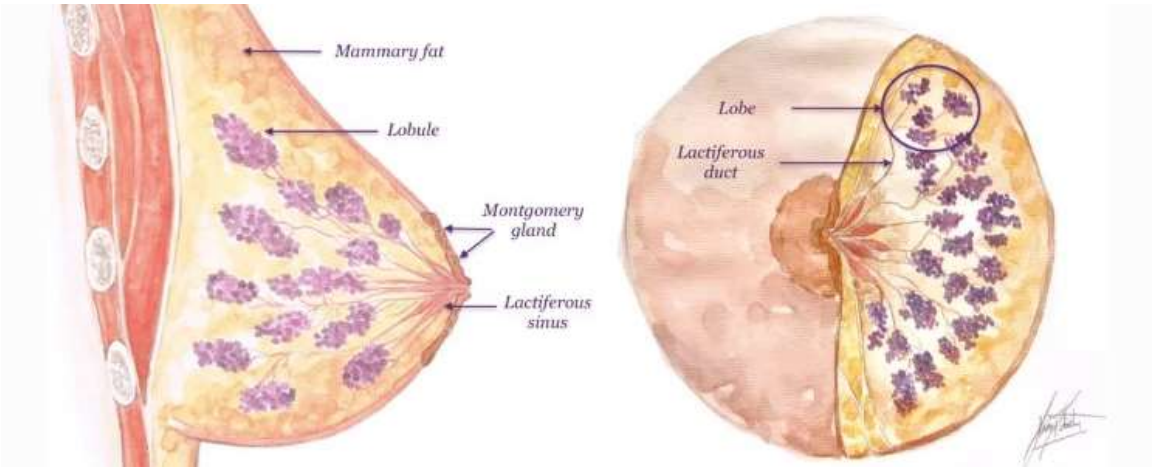

Figure 1: Anatomical structure of the breast (*glandula mammaria*), highlighting its histological organization. On the left, a sagittal section of the breast shows the mammary fat, lobules, lactiferous sinuses, and Montgomery glands. On the right, a magnified view of a lobe reveals the lobes, smaller lobules, and lactiferous ducts, which converge into lactiferous sinuses. The breast's structure is specialized for milk production and secretion, supported by alveoli lined with glandular epithelium and contractile myoepithelial cells, which facilitate milk ejection.

The size and composition of the breast tissue can vary between individuals and even within different regions of the same breast, often influenced by age, hormonal status, and functional activity (Hayes & Nguyen, 2014). The breast undergoes dynamic changes throughout a woman's life, including ductal growth and alveolar proliferation during puberty, rapid expansion and secretion during pregnancy, and eventual regression during menopause. During pregnancy, the ductal system grows extensively, forming new terminal ducts and alveoli, which become fully differentiated by late gestation to facilitate milk secretion. Following menopause, glandular tissue is replaced by fibrous and fatty tissue as hormonal stimulation decreases (Dahmane & Cör, 2001). These functional changes are influenced by hormonal cycles and are essential for the breast's role in lactation and reproduction (Hayes & Nguyen, 2014). Understanding these histological variations is crucial for diagnosing and managing breast diseases.

5. Lymphatic system

The human lymphatic system, comprising lymphatic vessels, lymph nodes, and lymphoid organs such as the tonsils, thymus gland, and spleen, plays a critical role in maintaining tissue–fluid balance and body homeostasis (Leong et al., 2022; Natale et al., 2021). Functioning parallel to the venous system, it has primary responsibilities that include clearing interstitial fluid and substances that cannot be reabsorbed into venous capillaries, transporting food lipids (e.g., chylomicrons absorbed in the intestine), and returning lymphocytes from lymphoid organs to the bloodstream (Schuenke et al., 2010).

The lymphatic vascular system consists of lymphatic capillaries, vessels interspersed with lymph nodes, and major trunks such as the thoracic duct and right lymphatic duct. Peripheral lymphatic capillaries, which begin as blind-ended vessels, collect interstitial fluid and transport it through lymphatic vessels and nodes to major lymphatic trunks. These trunks return lymph to the venous system at the junctions of the subclavian and internal jugular veins (Schuenke et al., 2010). Lymph nodes, small bean-shaped structures situated along lymphatic vessels, act as filtering stations and secondary immune centers. Afferent lymphatic vessels bring lymph into the nodes, where macrophages and lymphocytes cleanse it of pathogens and debris. The filtered lymph then exits through efferent vessels, continuing its journey toward major ducts and the venous system (Null et al., 2023).

The axillary lymph nodes (**Figure 2**) serve to drain the entire upper limb, the breast and the trunk above the umbilicus and are categorized into groups (Khan et al., 2025):

- Anterior (pectoral) nodes are located along the lower border of the pectoralis minor, behind the pectoralis major muscle. They receive lymph vessels from the lateral quadrants of the breast and superficial vessels from the anterolateral abdominal wall above the level of the umbilicus. There are usually 4-5 large nodes in this group.
- Posterior (subscapular) nodes, consisting of 6-7 nodes, lie in front of the subscapularis muscle and receive superficial lymph vessels from the posterior trunk down to the level of the iliac crests.
- Lateral nodes, comprising 4-6 nodes lie along the medial side of the axillary vein and receive most of the lymph vessels of the upper limb, except for superficial vessels draining the lateral side (see infraclavicular nodes below).
- Central nodes, located in the center of the axilla within the axillary fat, receive lymph from the anterior, posterior, and lateral groups and typically consist of 3-4 nodes.
- Apical nodes, also referred to as the subclavicular group, are found at the apex of the axilla near the lateral border of the first rib. These nodes collect the efferent lymphatic drainage from all the other axillary nodes.
- Infraclavicular (deltopectoral) nodes are not strictly axillary nodes, since they are located outside the axilla. They lie in the groove between the deltoid and pectoralis major muscles and receive superficial lymph vessels from the lateral side of the hand, forearm, and arm.

The lymphatic system also plays a pivotal role in disease processes, particularly cancer. Unlike the cardiovascular system, the lymphatic network consists of nearly invisible, fragile vessels that transport clear, colorless lymph. This system is the main pathway for the spread of cancer cells, with malignant cells colonizing lymph nodes and distant organs, leading to a poorer prognosis in breast cancer patients. Mapping lymphatic flow patterns could enable the prediction of tumor spread based on the primary tumor site. (Leong et al., 2022; Natale et al., 2021).

6. Breast Carcinoma

Breast carcinoma is the leading cause of cancer related deaths among women (Keen & Davidson, 2003). According to WHO (2024) it is believed that breast cancer caused approximately 670000 deaths globally in 2022. Only 0,5–1 % of breast cancer occurs in men, other 99 % cases occur in women. The strongest risk factor is gender, other risk factors are: age, obesity, increased alcohol consumption, a sedentary lifestyle, exogenous hormone exposure, including contraceptive pills and hormone replacement therapy, radiation exposure, family history of breast cancer and genetic predispositions (mutation of genes - BRCA1 and BRCA2 and others) etc (WHO, 2024). Although survival rates have significantly improved over the past two decades, the incidence of this disease continues to rise worldwide. The incidence increases with age, with over 80% of cases occurring in women over 50 (Nolan et al., 2023).

Breast cancer often presents as a painless lump in the breast or armpit. A lump is usually a palpable structure and can be of any type. Additional signs (**Figure 3**) may present as breast swelling, changes in shape or size of the breast as well as skin changes such as erythema, pitting, an "orange peel" texture (peau d'orange) and ulceration. Alterations to the nipple, such as inversion, skin changes, or discharge, may also occur (Katsura et al., 2022; Mohallem Fonseca et al., 2019). These breast lumps on the other hand can be a sign of inflammation, hyperplastic proliferation or just fluid accumulation. However neoplastic proliferations can be present without lump formation (Cserni, 2020).

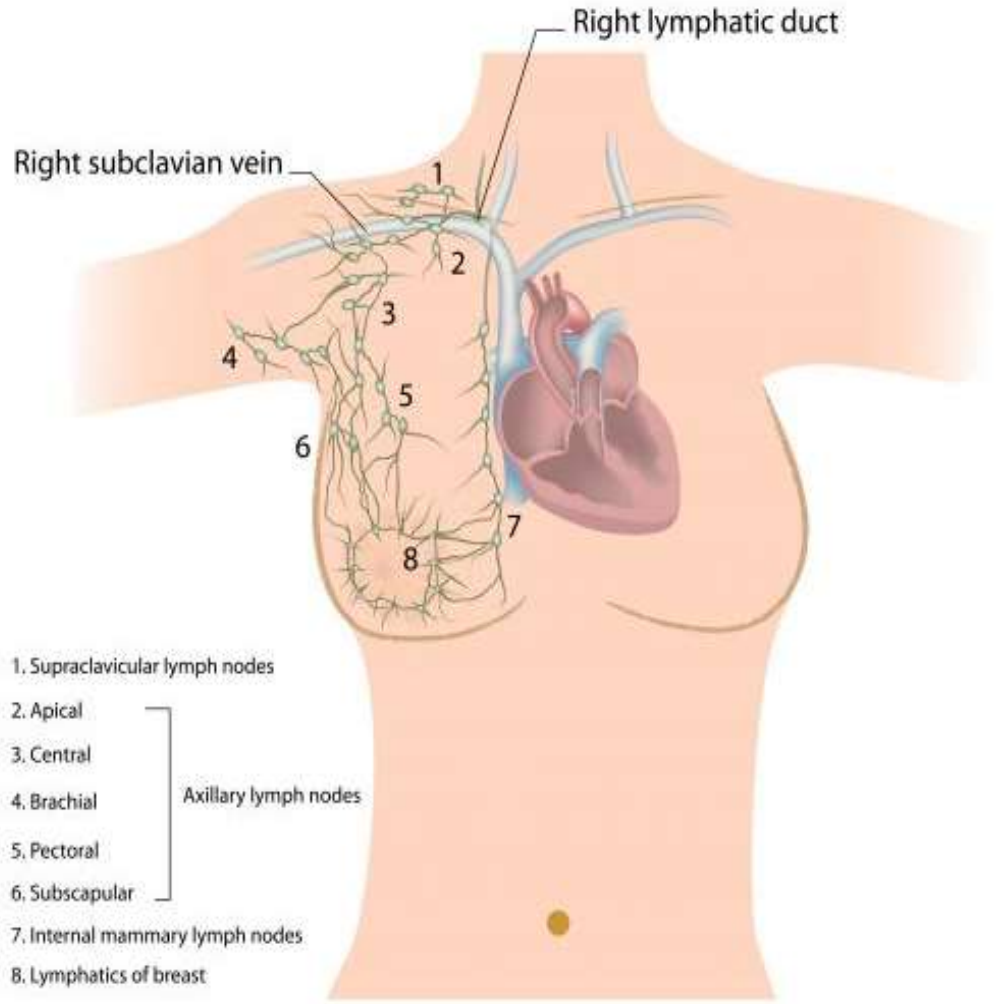

Figure 2: The lymphatic drainage of the breast, highlighting the lymphatic vessels and lymph nodes in the axillary region, involved in maintaining tissue-fluid balance and immune defense (Comans, 2019). These include the pectoral, central, subscapular, brachial, and apical groups, which collectively drain lymph from the breast, upper limb, and adjacent chest wall. The supraclavicular lymph nodes and internal mammary lymph nodes are also shown, representing additional drainage pathways. The right lymphatic duct connects this system to the right subclavian vein, demonstrating the integration of lymphatic drainage into the venous circulation

Breast tumors can be divided into benign and malignant. The main difference between benign and malignant tumors is that benign tumor cells do not spread, do not metastasize to other parts of the body, and rarely need to be treated. They can cause uncomfortable symptoms or changes in the appearance of the breast. Benign breast tumors include fibroadenoma, hamartoma, lipoma, and intraductal papilloma. Breast carcinomas can be classified according to histological grade or histological type. Histological grade assesses the degree of differentiation (tubule formation and nuclear pleomorphism), the proliferative activity of a tumour and mirrors its aggressiveness. The grades of breast carcinomas range from I. which is most similar to normal healthy cells, to III. which is the most different from normal cells and most aggressive. Histological type refers to the growth pattern of the carcinoma. Among the most common are ductal carcinoma in situ (DCIS) and invasive ductal carcinoma (IDC). DCIS is a non-invasive malignant carcinoma that originates in the lactiferous ducts and remains confined to the ductal system without spreading to surrounding tissues. It is considered an early form of breast cancer with high treatment success rates. IDC, on the other hand, arises from DCIS when the cancer cells invade surrounding healthy breast tissue. It is the most prevalent type of breast cancer and is capable of metastasizing to other parts of the body. Another significant type is invasive lobular carcinoma (ILC), which originates in the lobules. ILC tends to be bilateral and multicentric, often spreading to bones, ovaries, or serous cavities. Less common types of

breast cancer include inflammatory breast cancer, which presents with swelling and redness due to lymphatic blockage; tubular breast cancer, characterized by its tubular structure under microscopic examination; and colloid breast cancer, which produces mucin. (Weigelt et al., 2010). Breast cancer stage is determined by tumor size, nodal involvement, metastases and the presence of specific biomarkers such as estrogen receptors, progesterone receptors and ERBB2 receptor. DCIS is stage 0, noninvasive breast cancer. Early invasive cancer describes stages I, IIa, and IIb, and locally advanced cancer describes stages IIIa, IIIb, and IIIc. All of these stages of breast cancer are nonmetastatic. Stage IV is metastatic breast cancer. Breast cancer which do not express any of the specific biomarkers are referred to as triple-negative. Breast cancer is treated with preoperative and postoperative systemic therapies that include chemotherapy, endocrine therapies, immunotherapy with monoclonal antibodies directed at tumor receptors, surgery and radiation (Trayes & Cokenakes, 2021).

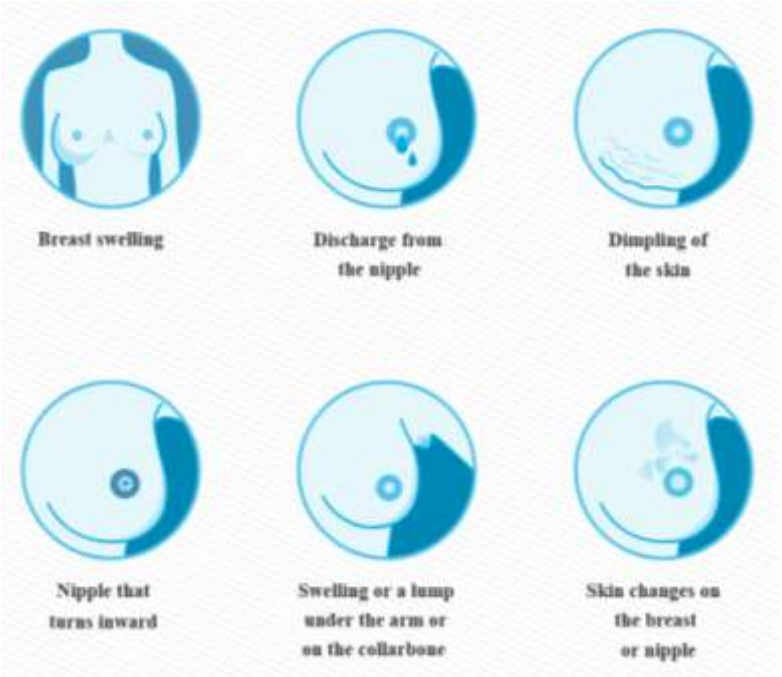

Figure 3: Common signs and symptoms associated with breast cancer (*Breast Cancer Symptoms and Signs,* n.d.). These symptoms highlight potential abnormalities that may warrant further medical investigation, as they can be indicative of underlying pathological processes, such as inflammation, fluid accumulation, or neoplastic proliferation.

7. Physical therapy approach after breast cancer surgery

Rehabilitation after breast cancer surgery is crucial for improving physical function, managing pain, preventing complications like lymphedema, addressing psychological well-being, and enhancing overall quality of life (Donahue et al., 2023). Breast cancer surgery can involve procedures that significantly impact the body (De Groef et al., 2015). Rehabilitation helps manage and improve physical function, flexibility, and strength that may be lost due to surgery (De Groef et al., 2015).

The primary focus of post-surgery rehabilitation is improvement of upper limb function, because many patients experience reduced mobility and function (De Groef et al., 2015). Addressing and managing pain effectively (Olsson Möller et al., 2019) and prevention and management of post-operative complications are primary rehabilitation goals especially after lymph node removal (Davies et al., 2020). Beyond physical recovery, rehabilitation must address the psychological impact of breast cancer (Olsson Möller et al., 2019).

Rehabilitation programs are designed to improve muscle function and range of motion, incorporating both active and passive stretching exercises, and strengthening routines for the shoulder girdle muscles (De Groef et al., 2015). Complete decongestive therapy, which

uses manual lymphatic drainage, the use of compression bandages, and skin care are part of the standardized rehabilitation protocol when managing lymphedema (Donahue et al., 2023). Kinesiology tapes can also be used (Yang et al., 2024). Physical Agents such as TENS and cryotherapy may help with pain reduction. Whereas advanced treatments such as low-level laser therapy (Davies et al., 2020) and hydrotherapy (Wang et al., 2022) play a significant role in reducing pain, enhancing tissue healing and lowering inflammation as well. Rehabilitation programs are tailored to meet the physical and emotional needs of the patient, ensuring they regain their strength, function and confidence to lead a more fulfilling life (De Groef et al., 2015).

8. Discussion

Breast anatomy and its clinical implications are particularly significant in the context of breast cancer, one of the most common malignancies affecting women worldwide. The mammary gland is comprised of glandular and adipose tissues and supported by connective structures. It is richly vascularized by branches of the internal thoracic, lateral thoracic, and thoracoacromial arteries, with venous drainage primarily directed into axillary and internal thoracic veins (NCBI, 2020; Cleveland Clinic, n.d.). The lymphatic drainage system is of paramount importance in the development of breast cancer, as the axillary lymph nodes are often the first sites of metastasis. In breast cancer, axillary lymph nodes are crucial for drainage from the upper limb and breast, as approximately 75% of lymphatic drainage flows into these nodes (Leong et al., 2022). The lymphatic system is the main pathway for cancer cell spread, making lymphatic mapping and evaluation essential for predicting tumour spread and prognosis. Early detection of metastasis can significantly impact treatment and outcomes in breast cancer patients (Khan et al., 2025).

Histologically, the breast undergoes dynamic remodelling influenced by hormonal changes throughout life, with notable changes during puberty, pregnancy, and menopause. The terminal duct lobular units, essential for lactation, are also the primary sites for the origin of most breast carcinomas, underscoring the need for a detailed understanding of breast histology to guide diagnosis and treatment (Hayes & Nguyen, 2014). Recognizing these changes is essential for understanding normal physiology and identifying pathological conditions, aiding in better diagnosis and treatment of breast-related diseases (Leong et al., 2022). Furthermore, correct diagnosis and treatment, aided with physical therapy is essential for patient-focused rehabilitation (De Groef et al., 2015).

Although the incidence of breast cancer rises, survival rates have been improving. In 2020 the World Health Organization reported 685000 deaths globally and by 2022 these rates had decreased further (WHO, 2024). This decline may be attributed to heightened public awareness regarding healthy lifestyle practices, such as reducing alcohol consumption, alongside significant improvements in early diagnostic measures, rapid treatment protocols, and prompt medical interventions (Nolan et al., 2023). Post-operative physical therapy is an integral component of breast cancer care, aiming to restore function, prevent complications, and improve the quality of life. Programs focus on improving upper limb mobility and strength through active and passive exercises, alongside specialized treatments like manual lymphatic drainage, compression therapy, and advanced modalities such as low-level laser therapy and hydrotherapy (Donahue et al., 2023; Davies et al., 2020).

In Slovenia, the standardized post-operative rehabilitation approach is structured and phased. Early post-operative physical therapy focuses on education, proper posture, and simple shoulder exercises, progressing to advanced active exercises and scar massage after suture removal. Health education, especially for lymphedema prevention, is emphasized from the outset. Outpatient therapy additionally ensures continuity of care (Institute of Oncology, 2019). Compared to international practices, the Slovenian protocol places a stronger emphasis on early education and the gradual progression of activities tailored to individual needs. While global protocols often recommend earlier, more aggressive mobilization and manual therapy, the Slovenian approach favours a more cautious, stepwise methodology to minimize complications like lymphedema and ensure patient comfort (Leong et al., 2022). This structured approach demonstrates the importance of integrating anatomical and histological knowledge with patient-centred therapeutic strategies to optimize outcomes.

9. Conclusions

The mammary gland is a complex organ consisting of glandular, adipose, and connective tissues, essential for reproductive and physiological functions. Its dynamic histology, shaped by hormonal changes, increases its vulnerability to diseases such as breast cancer, a persistent global health priority. Breast cancer frequently originates in the terminal duct lobular units, emphasizing the importance of detailed anatomical and histological knowledge for accurate diagnosis and treatment. Advances in understanding the lymphatic system have enhanced the prediction of cancer metastasis, a critical factor in prognosis. Although progress has been made in early detection and treatment, breast cancer remains a significant health challenge, with rising incidence rates underscoring the need for ongoing research. Post-surgical physiotherapy plays a vital role in recovery, addressing both physical impairments and emotional well-being.

Conflicts of Interest: The authors declare no conflict of interest.

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