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THE ANATOMY OF THE HUMAN BREAST

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INTRODUCTION:

The human female breast is an organ designed to produce milk for lactation, i.e., breastfeeding.[1] As such, it consists of epithelial components, lobules, in which milk is made, and these connect to ducts leading out to the nipple.[1] The male breast is virtually identical to the female breast except for the absence of the specialized lobules.[1] The structure and distinguishing characteristics of the breast as well as the bodily functions that support it all define how it functions and the aspects of the breast that make it potentially susceptible to cancer. This paper will detail the size, dimensions, and shape of the adult human breast, its surface anatomy and landmarks, boundaries and relations, parts/divisions/layers/composition, supporting structures, surgical access to the organ, blood supply and drainage, innervation, lymphatic drainage, histology/microscopic anatomy, normal and pathologic variants, and normal organ physiology.

SIZE, DIMENSIONS, SHAPE:

The human female breast is designed to support the physiology of lactation, which requires changes in breast size, shape, and composition during each of the three stages of female development: puberty, pregnancy, and lactation.[2] During each of these stages, the changes in the breast take place to support associated changes in the function of the breast. As described in the section on normal organ physiology, these changes are linked to new functions of the breast in each stage of development. The size of a woman's breasts is highly individual, as is the shape.[3] In general, however, the shape is dome-like in adolescents, becoming hemispheric in mature females, and then pendulous in parous females.[3] The female breast's weight and dimensions vary greatly from one woman to the next but are typically in the 500-1,000-gram range (i.e., 1.1-2.2 lbs.).[4] A breast weighing 500 grams (1.1 lbs.) or less is identified as small- or medium-sized, while a breast weighing 750-1,000 grams (1.7-2.2 lbs.) is identified as a large

breast.[4] The composition of a breast also varies from woman to woman, with some women having breasts with a more glandular structure, while others have more adipose or connective tissue.[4]

SURFACE ANATOMY/LANDMARKS:

The surface anatomy of the breast consists of the round protruding structure that contains the mammary gland, as well as adipose tissue and dense connective tissue.[10] The pigmented area at the apex of the breast is the areola, and the central elevation is the nipple.[10] The blood vessels and nerves to the nipple run along a suspense septum that starts at the pectoral fascia along the fifth rib, and two vertical septa, one along the sternum and the other at the lateral pectoralis minor muscle.[10] The inferior breast border inframammary ridge and the superior breast border second rib can also serve as landmarks enabling a surgeon to "position" the breast. Landmarks are especially useful when the skin-to-air and other boundaries are indistinct. Other landmarks, such as the pectoralis major muscle, latissimus dorsi muscle, and lateral border latissimus dorsi muscle are internal and therefore not as easy to pinpoint as external landmarks.

BOUNDARIES/RELATIONS

In general, it is difficult to detect breast boundaries because of imaging artifacts, the homogeneity between the pectoral and breast regions, uneven spatial distributions of pectoral muscle and glandular tissue, and low contrast along the boundary between the skin and the air.[5] Shi et al. developed "a fully automated pipeline of mammogram image processing" that estimates the skin-air boundary using gradient weight map and detects the pectoral-breast boundary by unsupervised pixel labeling, as well as detecting calcifications inside the breast region using a texture filter.[5] The authors used a gradient map for the skin-air boundary, calculating the weight for each pixel from the gradient magnitude at that pixel using a 3x3 cross

window to return the weight.[5] Then they performed breast segmentation based on pixel-wise clustering. Pectoral-to-breast grounding line detectors were emphasized using image fill and erosion.[5] A LAW's texture filter was used to detect calcifications.[5] The result was an imaging approach that bypasses the usual problems with effective breast imaging and that provides a scientifically devised visualization based on pixel weight that delivers a more reliable breast image. This image can more aptly detect and picture calcifications for diagnostic purposes.

PARTS/DIVISIONS/LAYERS/COMPOSITION:

The parts of the breast include the skin, nipple, areola, Montgomery's glands, Morgagni's tubercles, sweat glands, hair follicles, axillary tail, infra-mammary fold, and pectoralis major muscle.[4] The breast is divided into quadrants for the purposes of mammography, and these include the superior lateral (upper outer), superior medial (upper inner), inferior medial (lower inner), and inferior lateral (lower outer) quadrants.[6] The nipple is in the center of the breast, surrounded by the areola.[5] The layers of the breast include the fascial, adipose, connective fibrous) tissue, glandular tissue, lactiferous ducts, lobes and lobules, and alveolus.[4] The breast's composition is comprised of the contents of its layers, i.e., it is composed of fascia, fat, connective tissue, glands, and lactiferous ducts.

SUPPORTING STRUCTURES:

The adult breast sits on top of the pectoralis muscle of the chest, which is located over the ribcage, and the breast tissue extends sideways from the sternum to the midaxillary line.[1] There is a tail of breast tissue known as the "axillary tail of Spence," extending into the underarm area which can be a site of breast cancer.[i] Around the breast tissue is the fascia, which is a thin layer of connective tissue.[1] The fascia surrounding the corpus mammae, encasing it in two layers of fat and fascia, is called the superficial fascia system.[7] The circummammary ligament defines the

breast's perimeter: it is comprised of superficial fascia collagen fibers encasing a ring of fat.[7] As such,, this ligament anchors the deep fascia of the chest to the breast's perimeter.[7] There are also specialized cutaneous ligaments the Cooper ligaments, which go from the posterior lamina fascia through the breast gland and anterior lamina where they anchor in the skin.[7]

SURGICAL ACCESS TO ORGAN:

Surgical access to the breast depends upon the type of surgery being performed and whether the nipple and/or the skin will be spared. Since the breast has components external to the body, it can be visualized externally, but the location of a tumor must be done using technologies such as mammography or MRI and then externalized to the breast where it is usually marked prior to surgery. In general, the surgery is performed with the patient under general anesthesia with the arms positioned symmetrically 30 degrees away from the chest.[8] The sharp dissection is begun with a no. 10 blade, and the nipple-areola complex (NAC) is elevated off the underlying breast parenchyma. The surgeon takes care to leave a 1-2 cm thickness of the retroareaolar glandular tissue to avoid retraction of the nipple.[8]

In a skin-sparing mastectomy (SSM), the total periareolar approach is used so as to keep the final scar at the transition at the natural border of the future NAC.[8] In therapeutic SSM, a central incision is made over the previous biopsy scar, which requires the original biopsy team to communicate with the oncoplastic surgery team.[8] A total periareolar incision is performed using delicate hooks and fiber optic retractors.[8] The breast tissue is dissected in the same subcutaneous layer, reaching the final margins of the breast parenchyma.[8] Skin flaps are handled carefully to preserve the integrity of the subdermal plexus and avoid excessive skin flap traction and dermal exposure.[7] A minimum skin flap thickness of 3-5 mm is maintained.[8] After completion of the

surgery, the incision is closed layer by layer with interrupted subcutaneous Vicryl 4-0 sutures and a continuous Prolene 4-0 suture.[8]

Depending upon the type of cancer, the stage of cancer, and the surgery being done, there may be various options. For example, in cases where the cancer has not spread to the lymph nodes, a simple lumpectomy may be performed that can spare the nipple and much of the breast tissue. If the cancer has metastasized, not only the breast but also some of the lymph nodes may need to be excised.

BLOOD SUPPLY/DRAINAGE:

The internal mammary, which is a branch of the subclavian artery, provides the blood supply to the breasts.[9] Additional blood supply is provided from the axillary artery's thoracic branch.[9] The veins that drain the blood from the breasts then take it to the superior vena cava, which enters the right side of the heart.[9] From there, the blood is pumped directly to the lungs, where it is oxygenated, then returned to the left side of the heart before being distributed throughout the body.[9] Sloane contends that "the rather direct route from the breasts to the lung capillaries may be significant in the metastasis (spread) of breast cancer."[9(p197)] The implication is that if cancer exists in the breasts, it could metastasize to the lungs by means of the capillaries.

INNERVATION:

The breast's innervation is provided by the intercostal nerves' anterior and lateral cutaneous branches.[10] The fourth nerve provides the primary nerve supply to the nipple.[10] Breast innervation is also supplemented by the lateral and anterior cutaneous branches of the second, third, and sixth intercostal nerves, in addition to the supraclavicular nerves.[10] The majority of cutaneous nerves extend into a plexus deep up to the areola.[10] There is variation among individuals and between the two breasts of a single individual as to the extent of

intercostal nerve supply to the breast.[10] In many women, the breasts are also supplied by the first and/or seventh intercostal nerves.[10] Fibers from the third and fifth intercostal nerves may also augment the supply to the nipple.[10]

Sensory fibers from the breast send tactile and thermal information to the central nervous system.[10] Cutaneous sensitivity of the breast varies from woman to woman but is consistently greater above the nipple than below it. The areola and the nipple are the most sensitive areas of the breast and the most important for sexual arousal in many women.[10] This is likely due to the high concentration of nerve endings in the nipple.[10] Small breasts have greater sensitivity than large breasts, with large-breasted women reporting relatively little sensation in the NAC.[10]

Although the nipple's apical surface has an abundance of nerve endings, including free nerve endings and Meissner's corpuscles, the sides of the nipple and the areola are less highly innervated.[10] The nipple's dermis is supplied by branched free nerve endings that are sensitive to multiple types of input.[10] Nipple innervation is critical since normal lactation requires stimulation from infant suckling. The peripheral skin receptors are specialized for stretch and pressure.[10]

Efferent nerve fibers that supply the breast are mainly postganglionic sympathetic fibers that innervate smooth muscle in the skin and subcutaneous tissues' blood vessels.[10] Sympathetic fibers also innervate the nipple's circular smooth muscle, which causes nipple erection, the smooth muscle around the lactiferous ducts, and the arrector pili muscles.[10] Innervation is also critical to breastfeeding, as the nipple surface must open in order to permit the milk to flow.[10]

LYMPHATIC DRAINAGE:

Lymphatic drainage of the breasts is also germane to the discussion of breast cancer. The body produces the lymph, which is also termed "tissue fluid," from blood plasma.[9] The lymph transports food and oxygen to the body's cells and is reabsorbed at the ends of the capillaries.[9] Since not all of the fluid is absorbed, the excess passes into tiny lymphatic capillaries.[9] Lymph is drained from the lymphatic capillaries into progressively larger lymphatic vessels, and eventually into a major vein near the heart.[9] This drainage prevents the body from swelling, or edema, due to retention of fluid.8 In the breasts, most of the lymph from the mammary gland's center, skin, nipple, and areola drains laterally toward the axilla.[9]

The low axillary nodes are the first encountered, and from there the lymph passes to the central axillary nodes, which are embedded in a pad of fat in the center of the armpit.[9] The lymph then flows to the upper part of the axilla to the lateral nodes along the axillary vein and then to the deep axillary or subclavicular nodes.[9] The lymph is drained from the back of the breast to several interpectoral nodes located between the pectoralis major and the pectoralis minor muscles.[9] The internal mammary nodes that lie along the sternum are in the lymph channels' pathway that drain from the inside (medial) part of the breast.[9]

When breast cancer cells invade the lymphatic system via metastasis, they first reach lymph nodes, which retain the tumor cells and try to destroy them.[9] However, the malignant cells grow rapidly and proliferate, eventually overcoming the nodes' capacity for destroying them.[9] Then the cancer spreads on to other noes.[9] Since 75% of the breast lymph drains into axillary nodes, it is believed that removing the primary tumor in the breast plus the axillary nodes can often completely eradicate the cancer.[9]

HISTOLOGY/MICROSCOPIC ANATOMY:

Pathologists use breast tissue biopsies to histologically assess the microscopic structure and elements of the breast tissue.[11] The aim of histopathology is to distinguish between normal (benign/non-malignant) tissue and malignant lesions and to perform a prognostic evaluation. [11] Computer-aided diagnostic approaches are used to improve the diagnostic accuracy.[11] Here, a computational approach is presented based on deep convolution neural networks for classifying breast cancer histology images.[11] The authors used hematoxylin and eosin stained histology microscopy images and utilizes several deep neural network architectures and a gradient-boosted trees classifier.[11] They report 87.2% accuracy on four-class classification tasks and 93.8% accuracy on two-class classification tasks to detect carcinomas.[11] They also report AUC 97.3% and a sensitivity/specificity of 96.5/88.0% at the high-sensitivity operating point.[11]

EMBRYOLOGY; DEVELOPMENTAL ANATOMY:

Breast embryology begins in the fetal development stage. The breast structure development occurs in and beyond the 15th week of gestation, when the fetal mammary gland becomes responsive to maternal steroid hormones.[11] These changes are evidenced in the last weeks of gestation by the secretion of colostrum and the palpable enlargement of the breast buds.11 This breast enlargement and secretion of fluid occurs in approximately 60% of normal newborns, but both of these phenomena resolve spontaneously during the first or second month following birth because of the disappearance of the mother's hormones from the infant's bloodstream, with no treatment necessary.[11] It can also take place in both male and female infants.[11] Then the development of the alveoli and their surrounding supportive framework remains inactive until puberty, with the breast tissue dormant during childhood.[11] It is essential to avoid surgery around the breast bud in young girls to prevent injury and possible growth disturbance.[11]

NORMAL AND PATHOLOGIC VARIANTS:

Normal breast physiology is based on normal genetic make-up. Normal variants can include genetic markers for breast size, for example. However, there are pathologic gene variants that can cause breast cancer, the most notable being the BRCA1 and BRCA2 genes.[12] In fact, breast cancer is the most common female cancer globally, with the majority of these arising spontaneously and nearly one-third having a heritable component.[12] The type of variant involved can govern how the cancer functions, as well; HER2 negative invasive lobular cancers, for example, tend to be more hormone-sensitive.[12] In addition, approximately 70% to 80% of breast cancers overexpress the estrogen receptor gene.[12] Basu et al. identify four types of hormone receptor cancers: Luminal A (hormone receptor positive and HER2 negative), Luminal b (hormone receptor positive and HER2 positive or negative), Triple negative breast cancer (TNBC)basal-like (hormone receptor negative and HER2 negative), and HER2-enriched (HER2 positive and ER/PR negative).[12]

NORMAL ORGAN PHYSIOLOGY:

The normal physiology of the female breast is based on its development to support the development of the mammary gland (mammogenesis), lactogenesis, and lactation.[2] The first change occurs in puberty, when lobule type 1 is formed; then as the menstrual cycle promotes changes in the estrogen and progesterone levels, lobule 1 is stimulated to produce new alveolar buds and ultimately to evolve into the more mature structures, type-2 and type-3 lobules.[2] After the completion of puberty, the breast does not undergo any further changes until pregnancy.[2]

During pregnancy, higher levels of progesterone initiate stage-II mammogenesis in which alveolar development occurs and the epithelium matures.[2] Breast volume increases during pregnancy because secretory tissue proliferates.[2] In the early stage of pregnancy, the formation

of lobule type 3 occurs in response to chorionic gonadotropin.[2] These newly developed lobules are larger and contain a greater number of epithelial cells in each acinus.[2] In the late stage of pregnancy, there is less proliferation of new acini, and the lumen enlarges as it fills up with secretions or colostrum.[2]

During labor and lactation, the lobules grow and differentiate further as milk secretion increases.[2] The breast's glandular component has now developed to the point where it consists primarily of epithelial elements and little stroma, a condition that will last during the entire lactation period.[2]

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