



Breast development in pediatric patients from birth to puberty: physiology, pathology and imaging correlation

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Received: 21 August 2020 / Revised: 1 March 2021 / Accepted: 2 May 2021

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Abstract

Breast tissue undergoes a series of changes from birth to puberty. The majority of the changes are transient, related to physiological hormonal changes. Although the breast is identical in both sexes at birth, its histology and development will eventually differ. It is important for radiologists to have a basic understanding of endocrinological changes and appearance on imaging to avoid potential pitfalls, particularly on ultrasound, which is the primary modality used to evaluate the breast.

Keywords Breast · Breast bud · Breast ducts · Children · Development · Gynecomastia · Ultrasound

Introduction

Boys and girls undergo endocrinological changes that influence normal breast development until puberty. In some children, these hormonal changes can lead to an unusual but transient appearance, potentially becoming a source of anxiety to patients and their parents and a source of confusion to clinicians and radiologists. From birth to puberty, pathological conditions of the breast are mostly benign and very often a transient part of normal development. Furthermore, malignant breast lesions, especially the adult-type primary breast carcinoma, in the pediatric population are exceedingly rare [1–3]. Most breast changes in the pediatric population can be diagnosed clinically, but sometimes imaging evaluation is recommended. Ultrasound (US) is the imaging modality of choice to evaluate the breast in pediatrics [4, 5]. Thus, familiarity with these transient changes and the occasional pathological conditions is important in order to avoid unnecessary and costly work-up and to prevent stress and anxiety for patients and parents.

In this article, we focus on some basic but key endocrinological principles, normal physiological changes of the pediatric breast and its variants, and common pathologies of breast development throughout childhood and adolescence. We also describe the US appearance of the normal breast in childhood and adolescence, physiological variations and certain pathological conditions that occur during this period. As the focus of this article is the spectrum of breast development throughout childhood, breast neoplasms are not discussed.

Imaging of the breast in the pediatric population

Ultrasound is the imaging modality of choice to evaluate the developing breast in pediatric patients and patients younger than 30 years of age, according to the American College of Radiology (ACR) Appropriateness Criteria [6]. Ultrasound is readily available, lacks ionizing radiation and does not require sedation, enabling good characterization of breast parenchyma and lesions. Because of the high density of the breast tissue in adolescents, the associated radiation exposure and the rarity of primary breast carcinoma seen in adult women, mammography plays virtually no role in the pediatric population [1, 4, 6–9]. Awareness regarding the sensitivity of the developing breast to invasive procedures, even fine needle aspiration, is of utmost importance because they can cause permanent breast bud arrest or deformity [10]. Therefore, breast procedures must be carefully scrutinized, making

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adequate interpretation of clinical and imaging findings in pediatric patients necessary [9].

When performing breast US in children, we have found it extremely helpful to scan not only the region of interest, but also the entire breast as well as the contralateral asymptomatic breast as a reference for normal anatomy. A high-resolution probe should be used, ideally a 15-MHz probe; however, if the breast is large enough, a 9-MHz probe should be used because the pectoralis muscles and rib cage must be visualized on the exam. Still and cine images should be routinely obtained and, when necessary, color Doppler can be applied. A standoff pad can be useful to evaluate a very small breast bud or very superficial or retroareolar areas.

Breast development in utero

The mammary gland is considered a highly modified sudoriferous (sweat) gland enveloped by superficial thoracic fascial layers and suspended from the chest wall by Cooper ligaments (in girls), extending from the pectoralis fascia to the dermis [8, 11, 12]. Breast development begins during the fifth to sixth weeks of gestation with the invagination of epidermal cells into the deeper mesenchyme, forming the primary mammary ridges or milk lines. These ridges extend from the axilla to the groin; however, only those at the level of the fourth intercostal space develop into breasts. The areola develops in the fifth month of fetal life. Soon after birth, the nipple becomes everted due to proliferation of the underlying mesoderm [11].

Breast changes in the newborn period

Normally, levels of gonadotropins at birth are low due to high levels of placental estrogen. After birth, estrogen levels decrease with subsequent elevation of gonadotropins and sex hormones in the following weeks [13]. During the newborn period, the breast is a rudimentary organ with identical histology in both sexes consisting mainly of simple branched ducts supported by stromal connective tissue; however, it is capable of responding to hormonal stimuli (i.e. placental or endogenous from the child) [11].

Neonatal breast enlargement

The placenta is the major source of estrogens during the third trimester, which influences breast development in fetuses and newborns of both sexes [13]. Thus, the commonly used term “maternal hormonal stimulation” is not accurate because there is no direct in utero transfer of hormones (i.e. estrogens) from the mother to the fetus. Neonatal breast enlargement is a

physiological, transient phenomenon seen in approximately 70% of neonates that usually presents around the first week of life [14]. It can be unilateral or bilateral and affects both sexes. Clinically, at birth, full-term babies have different degrees of palpable breast tissue, which tends to be more pronounced in girls (Fig. 1), and approximately 5% of neonates develop galactorrhea from neonatal prolactin stimulation, colloquially known as witch’s milk [15]. Occasionally, and in part due to parental anxiety, a breast US is ordered. On US, the prominent breast bud is seen as a retroareolar, hypoechoic, well-defined nodule containing a varying number of round and tubular cystic structures representing primitive ducts with some degree of branching and supporting stroma. At this age, no lobular parenchyma or fat is seen, as the breast bud is composed of secretory ducts only (Fig. 1) [16].

Neonatal mastitis (mastitis neonatorum)

Neonatal mastitis or mastitis neonatorum is an inflammatory process that occurs during the first 2 months of life (peak incidence around 3 weeks of age), affecting the hormonally

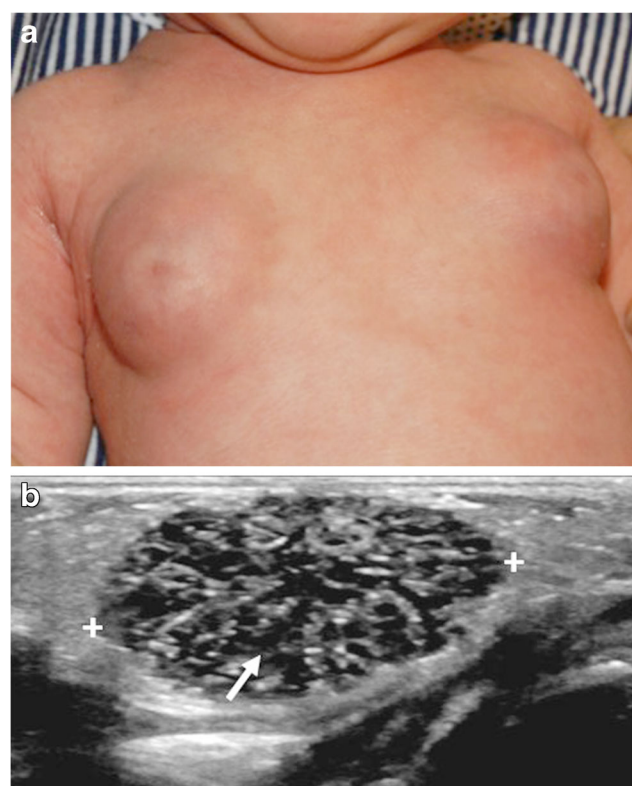


Fig. 1 Neonatal breast enlargement in a 4-week-old full-term girl. **a** A clinical photograph shows enlargement of both breast buds without prominence of the nipple-areolar complex. **b** A grey-scale sagittal ultrasound image shows a stimulated, enlarged, oval-shape right breast bud (calipers) with tubular and round interconnecting cystic channels (arrow) corresponding to dilated mammary ducts. Similar findings were seen on the contralateral breast

stimulated breast of full-term babies [17, 18]. *Staphylococcus aureus* is the pathogen in the majority of the cases; however, gram-negative organisms have been implicated as well, mainly when the source of the infection is hematogenous. Neonatal mastitis is almost always unilateral with a female-to-male ratio of 2:1 [17–19].

Neonatal mastitis is diagnosed clinically as swelling, erythema, tenderness and induration of the breast, with occasional nipple discharge (Fig. 2). Systemic symptoms, including fever, are uncommon, but cases of sepsis have been reported

[19, 20]. On US, neonatal mastitis is seen as enlargement and indistinctness of the breast bud with variable degrees of increased echogenicity and stranding of the surrounding subcutaneous soft tissues and hyperemia on color Doppler [19]. In the case of an abscess, a hypo- or anechoic fluid collection with a distinct, echogenic wall, debris, and peripheral hyperemia is seen (Fig. 2) [3, 19]. Neonatal mastitis is treated with systemic antibiotics. If an abscess is present, needle aspiration under US guidance is preferred to open incision and drainage in order to minimize permanent iatrogenic damage to the developing breast bud [19].

Breast changes in infancy and the concept of mini-puberty of infancy

In utero, fetal gonadotropin levels peak during mid-gestation, subsequently decrease and thereafter remain unchanged until birth. This is due to the negative feedback loop within the fetal hypothalamic–pituitary–gonadal (HPG) axis and is caused by a gradual increase in placental estrogens toward the end of pregnancy [13].

At birth, infants of both sexes are subjected to an abrupt withdrawal of placental hormones, and their HPG axis is released from the inhibitory effect by the placental estrogens. At approximately 1 week of age, as the activity of the HPG axis is reinitiated, there is a progressive and significant surge of the infant's gonadotropins and sex steroids. Luteinizing hormone (LH) concentrations in boys are within the pubertal range by 1 to 2 weeks of life and peak between the first and third months of life. LH and testosterone decline slowly to reach typical prepubertal childhood values by around 4 to 6 months of age. In girls, on the other hand, the follicle stimulating hormone (FSH) peaks between 2 and 4 months of age and decreases by around 12 months of age with measurable hormone levels up to 2 years of age [13, 21]. This period, characterized by gonadotropin and sex steroid surge, is known as the mini-puberty of infancy. This transient physiological phenomenon tends to be more pronounced and prolonged in premature infants [13, 21].

During the mini-puberty of infancy, there are wide variations in the degree of glandular development (ductal branching and acinar formation) and in the functional differentiation of the cells lining the ducts and acini, ranging from simple blunt-ended tubular structures to well-developed branching ducts with acinar development [11]. Clinically, while in some girls the hormonal effect on the breast bud is imperceptible, others might develop very prominent breasts (Fig. 3) that can cause parental anxiety, prompting imaging (US) not only of the breast but of the ovaries and uterus. On US, breasts show a more solid echotexture (Fig. 3), similar to mature breasts. Due to the stimulating surge of FSH, the ovaries might have a multifollicular appearance even with a

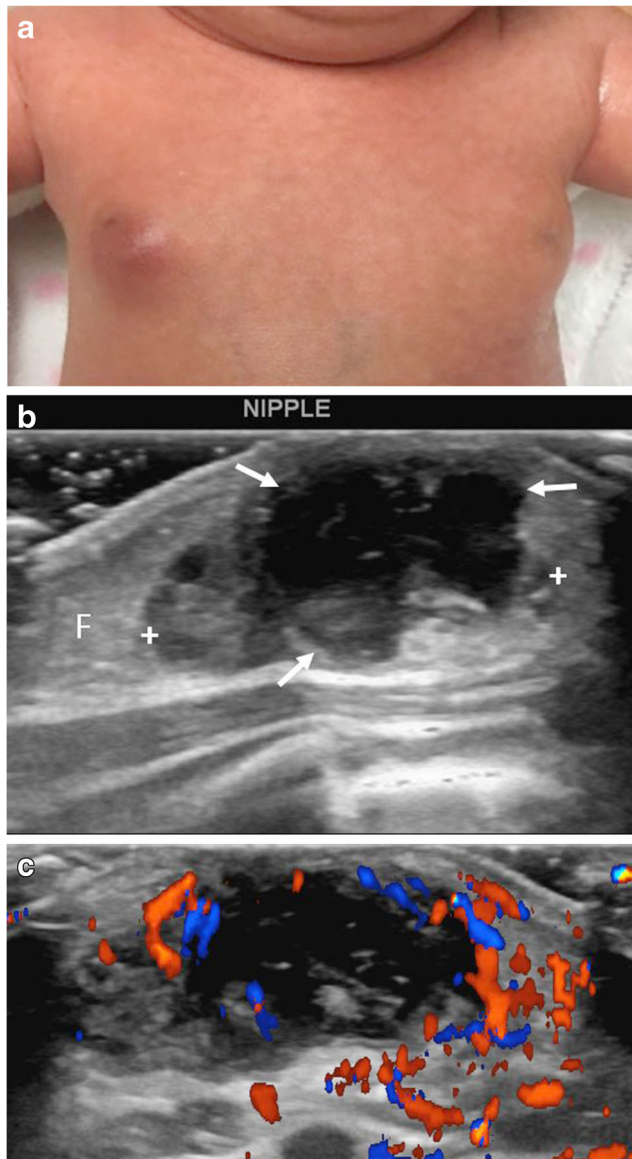


Fig. 2 Neonatal mastitis with abscess in a 3-week-old full-term girl. **a** A clinical photograph shows enlargement of both breast buds with erythema on the right. **b** A grey-scale transverse ultrasound image of the right breast bud shows a round, cystic structure (arrows) with internal echoes increased through transmission involving most of the breast bud (calipers). Stranding of the adjacent fat is present (F). **c** A color Doppler transverse ultrasound image shows peripheral hyperemia surrounding the abscess

dominant follicle, and the uterus might be enlarged with visualization of an endometrial stripe that on rare occasions can lead to menstruation [11, 22].

Infantile mammary duct ectasia

Mammary duct ectasia is the dilation of the mammary ducts associated with periductal inflammation. Although the etiology has not been well established, it has been postulated that this could be a developmental finding [23]. Postmortem histological findings in otherwise healthy children have shown large dilated mammary ducts, especially in children between 3 weeks and 3 years old [24]. Clinically, the most common presentation is bloody nipple discharge (Fig. 4), but it can also manifest as a palpable mass. Mammary duct ectasia at this age can be a manifestation of the mini-puberty of infancy. In children older than 1 year of age, mammary duct ectasia is four times more common in boys than girls, and it is secondary to ductal blockage, bleeding or inflammation [22]. Histologically, there is ductal dilatation with inflammation and hemosiderin-laden macrophages inside the ducts. On US, mammary duct ectasia is seen as a cluster of subareolar,

tubular or round cystic structures of different sizes (Fig. 4), sometimes with associated debris or septations. The findings can be unilateral or bilateral and symmetrical or asymmetrical; however, enlargement of the affected breast bud or discernible, solid, glandular mammary tissue is minimal or absent [22]. Given the transient nature of this entity, conservative treatment with parental reassurance usually suffices [22, 23, 25, 26].

Breast changes in the prepubertal child (toddler and early childhood)

The normal breast gland, still maintaining the same composition and structure in boys and girls, remains quiescent from approximately 2 years of age to the onset of puberty in both sexes.

Gynecomastia in the prepubertal boy

Gynecomastia is the development of breast tissue in males. Prepubertal gynecomastia is infrequent and secondary to

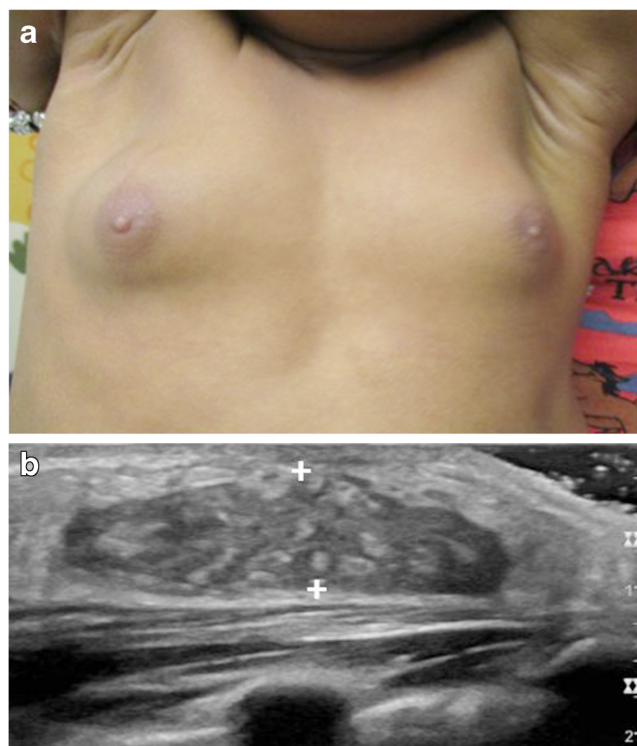


Fig. 3 Mini-puberty of infancy in a 16-month-old girl with prominent breast buds. **a** A clinical photograph shows significant, asymmetrical enlargement of both breasts with a mature appearance of the nipple-areolar complex. **b** A grey-scale sagittal ultrasound image of the right breast bud shows a prominent amount of hypoechoic breast tissue (*calipers*) with a lobular, solid appearance similar to mature breast. Similar findings were seen in the contralateral breast

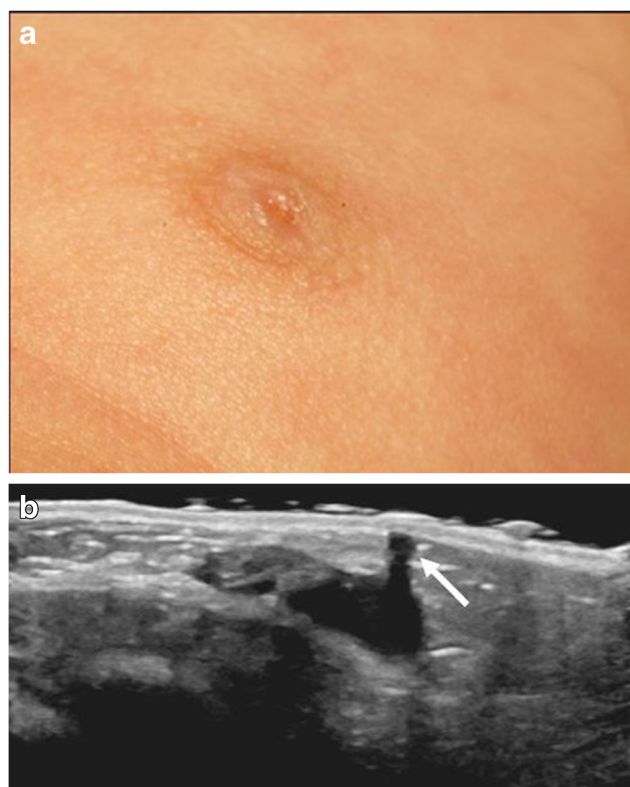


Fig. 4 Mammary ductal ectasia in a 6-month-old boy with left nipple discharge. **a** A clinical photograph of the left breast bud shows clear discharge from the left nipple. No breast bud enlargement is noticeable clinically. **b** A grey-scale transverse ultrasound image of the left breast bud shows a few cystic structures in the retroareolar region with a dominant one (*arrow*) directly communicating with the nipple consistent with dilated ducts

exposure to endogenous or exogenous estrogens, or estrogenic substances (Table 1). Therefore, when gynecomastia is present in prepubertal boys, further investigation should be carried out to search for an endocrinopathy. Endogenous estrogens that stimulate the breast can be produced directly by gonadal or adrenal tumors, by gonadotropin-secreting tumors such as hepatocellular carcinoma or choriocarcinoma, by aromatization from androgens associated with Sertoli cell and sex-cord testicular tumors, and in patients with Klinefelter syndrome [5, 27]. Tea tree oil, present in many cosmetic and hygiene products, and lavender products have been found to produce prepubertal gynecomastia due to their weak

estrogenic and antiandrogenic activity [28, 29]. However, in many cases, the etiology of prepubertal gynecomastia is not determined [30].

The clinical history should explore the timing of puberty and exposure to hormones or estrogenic substances. Clinically, there is enlargement of the breasts that can be unilateral or bilateral, and symmetrical or asymmetrical. Laboratory testing should include measurement of estrogens and their precursors. On US, the normal breast during this period shows subcutaneous fat, the nipple shadow and absent breast parenchyma. The US appearance of gynecomastia at this age is identical to the postpubertal type and will be discussed later [31].

Table 1 Causes of pathological gynecomastia

Exogenous intake of estrogens or estrogenic substances

Essential oils

Lavender

Tea tree

Phytoestrogens (soya)

Increased endogenous production of estrogens

Adrenal or testicular tumors

Aromatase excess

Androgen deficiency

Androgen insensitivity syndrome

Central hypogonadism

Primary hypogonadism (Klinefelter syndrome)

Antiandrogen medications

Bicalutamid

Flutamide

Spironolactone

5-alpha reductase inhibitors

Finasteride

Dutasteride

Other medications

Antihistaminics (Cimetidine)

Protease inhibitors

Antipsychotics

Chemotherapy agents

Methotrexate

Cyclophosphamide

Ketoconazole

Human chorionic gonadotropin

Anabolic steroids

Hypertension medications

Verapamil

Nifedipine

Marijuana

Alcohol

Opioids

Cirrhosis

Isolated premature thelarche and central precocious puberty in girls

Thelarche refers to the breast development in girls, which normally represents the onset of puberty. Thelarche typically occurs between 8 and 13 years of age [12]. Isolated premature thelarche is defined as transient development of breast tissue before 8 years of age without any other evidence of puberty. As previously discussed, isolated premature thelarche can occur between 6 months and 2 years of age, as part of the mini-puberty of infancy [11–24]. Breast development can be unilateral or bilateral, and typically there is absence of areolar enlargement [32]. Because this is a transient condition, progression to puberty and menarche will occur at the expected age [9]; however, close clinical follow-up is needed when it occurs after 2 years of age because precocious puberty is more likely [33]. When isolated breast development happens before 1 year of age, imaging or laboratory studies are not routinely recommended. If thelarche appears after 1 year of age and rapid growth velocity is detected, evaluation of gonadotropins, estradiol, bone age and pelvic US should be considered as part of the assessment [11–24].

It is important to distinguish isolated premature thelarche from central precocious puberty, both occurring in this age period. In central precocious puberty, there is a permanent activation of the HPG axis with breast development and ovarian and uterine enlargement. The ability of breast US to distinguish between isolated premature thelarche and central precocious puberty is limited; therefore, breast US is not part of the routine work-up [8, 34]. However, when persistent breast enlargement is unilateral or atypical findings upon physical examination are noted, imaging should be performed to exclude other breast or chest wall pathologies, mainly neoplasms [3, 5]. Breast malignancies at this age are rare and mainly metastatic in origin from widespread sarcomas or lymphoma. Focal protrusion of a chest wall neoplasm, such as a primitive neuroectodermal tumor, can also simulate breast enlargement [3–5, 9, 27, 35–37]. Similar to gynecomastia in boys,

premature thelarche at this age can also occur as the result of exposure to lavender and tea tree oil products [28].

Breast changes during puberty

Until this stage, breast histological composition and breast changes are similar in both boys and girls. It is not until puberty that the female breast undergoes a second, unique phase of differentiation and growth [10].

Breast changes in boys during puberty

At the beginning of puberty in boys, levels of estrogen increase transiently, stimulating the growth of breast tissue; however, this is quickly followed by a surge in testosterone, antagonizing the estrogen effect. The lack of a progesterone surge in boys precludes the development of terminal lobular units. This means that there is temporary proliferation of breast ducts and stroma followed by their rapid involution. Cooper ligaments are also absent in boys, whereas pectoralis muscles are more prominent than in girls. The sonographic appearance of the normal pubertal breast in boys is no different from its prepubertal appearance with visualization of subcutaneous fat and a faint nipple shadow [38–40].

Gynecomastia in the adolescent boy

Gynecomastia is defined as development of mammary glandular tissue in the male, more precisely ductal and stromal tissue proliferation, due to an imbalance of the testosterone/estrogen ratio [38, 41]. Gynecomastia is commonly seen during early and mid-puberty, with a reported incidence of 30% to 60% at this age [41].

Gynecomastia can be unilateral or bilateral, symmetrical or asymmetrical, and synchronous or metachronous. Laboratory testing usually fails to reveal abnormal circulating estrogen and/or androgen levels. Most cases of physiological gynecomastia resolve spontaneously as androgen levels continue to rise later in puberty, lasting no longer than 2 years [42, 43]. Upon physical examination, a subareolar, palpable, mobile lump, sometimes tender, is palpated. Occasionally, US is requested to rule out a mass or to differentiate it from pseudogynecomastia or lipomastia, which is the focal accumulation of adipose tissue, usually in overweight adolescents, that is always bilateral [40, 44]. Three patterns of gynecomastia have been described on US imaging: 1) a nodular pattern occurring in the early phase, seen as a hypoechoic disc-shaped mass beneath the nipple surrounded by fatty tissue (Fig. 5); 2) a dendritic pattern during the chronic phase, seen as a flame shape of hypoechogenicity in the retroareolar region with irregular margins that infiltrate the adjacent subcutaneous fat (Fig. 6); and 3) a diffuse pattern, seen on sonography, identical

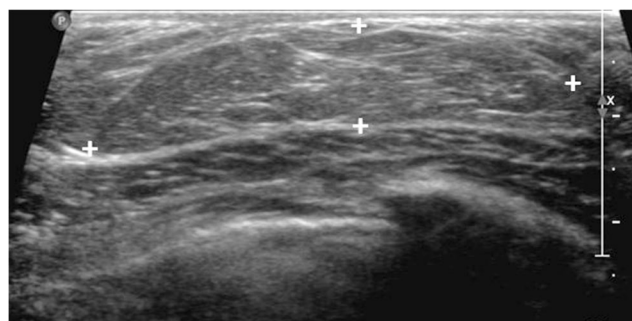


Fig. 5 Physiological nodular gynecomastia in a 13-year-old boy. A grey-scale, sagittal ultrasound image of the right breast shows disc-like hypoechoic tissue with distinct borders (*calipers*) in the retroareolar region

to the female dense heterogeneous breast [4, 38, 44, 45]. On US, lipomastia is seen as diffuse adipose tissue proliferation without fibroglandular tissue. No discrete mass should be present and, different from gynecomastia, no distinct borders

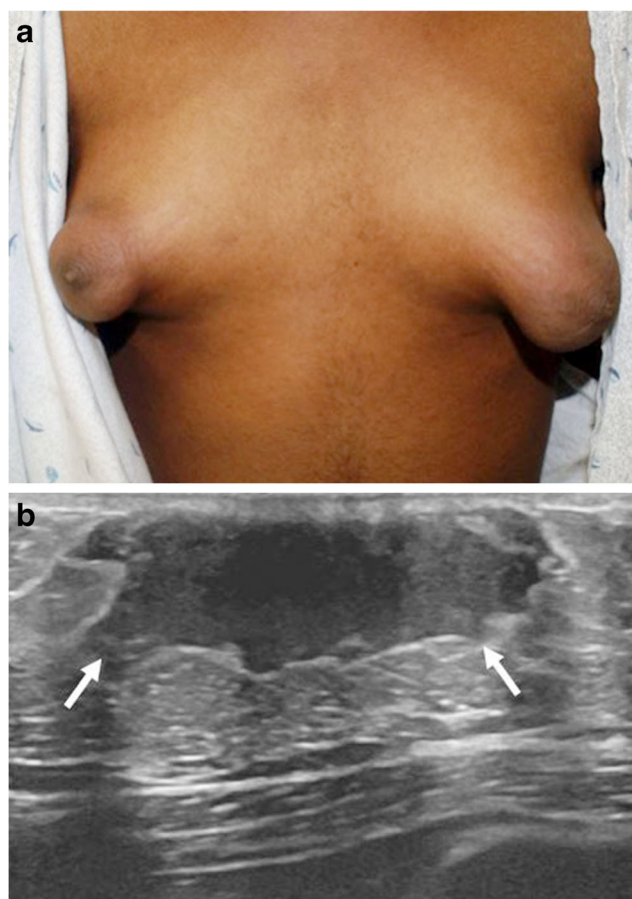


Fig. 6 A 16-year-old boy with a Leydig cell tumor of the testicle and secondary pathological gynecomastia for 2 years. **a** A clinical photograph shows significant bilateral gynecomastia. **b** A grey-scale sagittal ultrasound image of the right breast shows very prominent, hypoechoic, retroareolar breast tissue with finger-like projections (*arrows*) into the adjacent soft tissues consistent with long-standing dendritic gynecomastia. Nipple shadow is visualized. The contralateral breast had the same appearance

are identified (Fig. 7) [40]. Treatment is not necessary in most cases because physiological pubertal gynecomastia resolves spontaneously. However, when gynecomastia is severe and persistent, pharmacological treatment or surgery might be indicated [46].

Pathological gynecomastia is rare in pediatric patients and young adults, and it is secondary to elevated levels of exogenous or endogenous estrogens or to low production of testosterone [46]. The age of appearance and progression of gynecomastia are very important, with adolescents with late onset gynecomastia deserving a more detailed evaluation. A thorough clinical history, including age of pubertal development, exposure to hormones, medications with antiandrogenic actions, consumption of marijuana and family history of gynecomastia, should be explored (Table 1) [47]. US evaluation of the testicles is indicated when testicular asymmetry is found or a mass is palpated upon physical examination. If suspected, especially when FSH levels are elevated, a karyotype should be ordered to exclude Klinefelter syndrome.

Breast changes in girls during puberty

The first sign of puberty in girls is thelarche, which is considered normal after the age of 8 years, although, over the past decades, the appearance of breast tissue at younger ages has been reported. Some authors consider normal the development of thelarche among African American girls after the age of 6 years and among Caucasian girls after 7 years [48]. During the early phase of breast development, estrogens induce adipose tissue deposition, proliferation of the supporting stromal tissue and ductal elongation. Subsequently, progesterone induces ductal side branching that gives rise to acini, as well as alveolar budding, lobular growth, and secretory growth of lobules and alveoli. A collection of acini from one terminal duct and the surrounding stroma is called a terminal duct lobular unit, which is the functional unit of the female breast [8, 11, 23, 27, 49–51]. Normal development of the breast occurs over a 2- to 4-year period and is classified by the Tanner system into five stages [34]. Ectopic or accessory breast tissue occurs when there is incomplete regression of the

embryological milk line. Accessory breast tissue is most commonly located in the axilla, but it can be found from the axilla to the groin. Although present at birth, it usually manifests during puberty when it develops simultaneously with the normal breast. Accessory breast tissue has the same US imaging characteristics of normal breast parenchyma, but the location along the milk line is the most important clue for the diagnosis. It is important to recognize that an axillary mass corresponds to accessory breast tissue, as neither biopsy nor surgical excision is required [27].

Asymmetrical breast development during puberty

In some girls, asymmetry of the developing breasts can occur at any time, from infancy to adolescence, but it is usually more pronounced during puberty. On occasion, this asymmetry can be significant enough to raise concern in the patient and the clinician. Additionally, breast size discrepancy can be a disturbing cosmetic problem, leading to poor self-esteem and depression [52]. Most cases of breast asymmetry during puberty are thought to be physiological, and the diagnosis is usually elucidated by clinical exam and medical history. Routine imaging is not necessary; however, in some cases, US is requested to reassure the parents [9]. Likewise, when the growth is rapid and asymmetrical or unilateral, an underlying lesion (i.e. neoplasm) should be suspected, warranting imaging. During this period of breast development, due to the elevated levels of circulating estrogens, giant juvenile fibroadenomas that measure more than 5 cm and tend to grow rapidly can occur, leading to asymmetrical breast enlargement. US is helpful in confirming the diagnosis, showing a very large, homogeneous, solid and avascular mass, which, except for the size, is similar to any other fibroadenoma (Fig. 8) [4, 9, 53]. Breast asymmetry has also been reported as a postoperative complication of surgeries that require

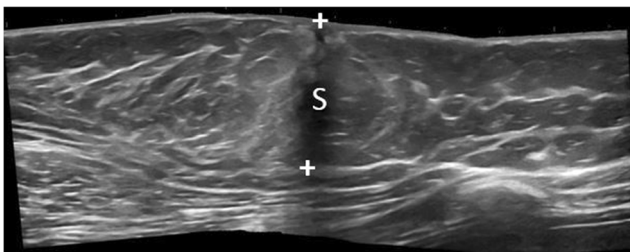


Fig. 7 Lipomastia in a 14-year-old obese boy. A panoramic grey-scale sagittal ultrasound image shows focal prominence of the subcutaneous fat (*calipers*) in the retroareolar region with no discernible borders and blending imperceptibly with the prominent adjacent layer of subcutaneous fat. *S* nipple shadow



Fig. 8 A 10-year-old girl with a biopsy-proven giant juvenile fibroadenoma presenting with rapid developing breast asymmetry. A panoramic grey-scale sagittal ultrasound image of the right breast shows a 10-cm, solid, slightly hypoechoic, homogeneous mass (*calipers*) with no identifiable breast tissue

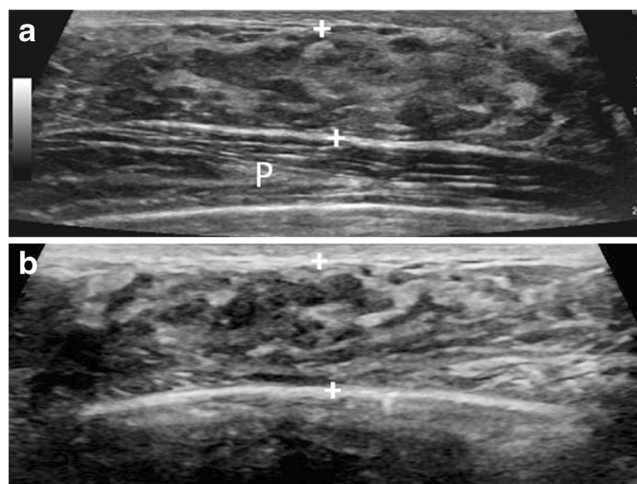


Fig. 9 Poland syndrome in a 14-year-old girl with left hypomastia. **a** A grey-scale transverse ultrasound image of the normal right breast shows a larger amount of breast tissue (*calipers*) compared to the left, and a normal pectoralis muscle (*P*). **b** A grey-scale transverse image of the left breast shows diminished breast tissue (*calipers*) and the absence of the pectoralis muscle compared to the right

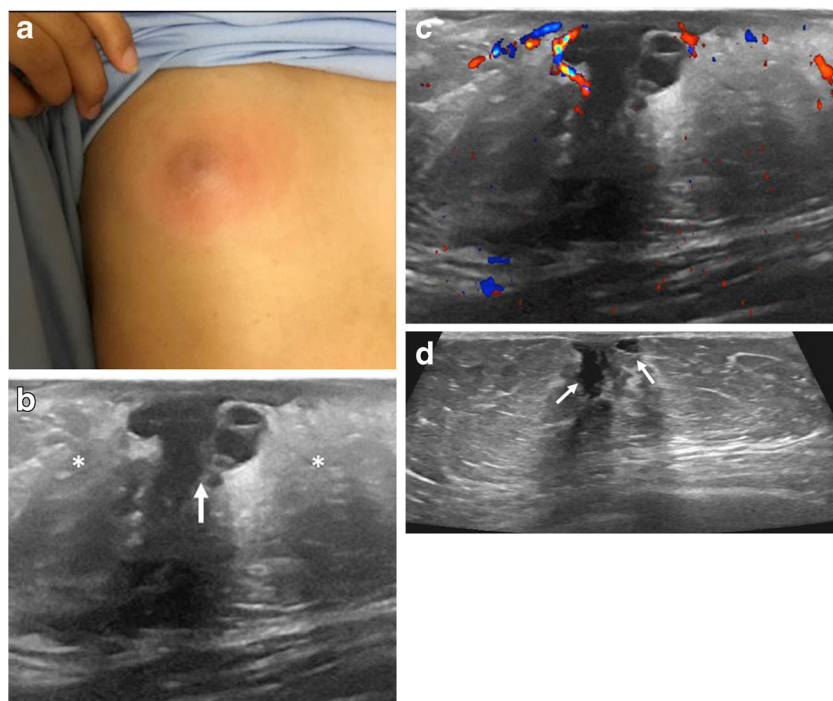
thoracotomy in early childhood [12, 54]. Breast asymmetry is frequently seen in girls with scoliosis; however, the unequal breast size is not real but rather pseudoasymmetry caused by the rib cage deformity [9]. Physiological breast asymmetry requires no treatment other than observation and parental reassurance. True breast asymmetry can be congenital in cases of amastia, hypomastia and Poland syndrome. In amastia, the mammary ridge fails to develop or involutes completely and is usually associated with other ectodermal defects. Poland syndrome is a

rare congenital anomaly characterized by a complete unilateral absence of the chest wall musculature with ipsilateral thoracic cage and upper limb defects. Breast anomalies in Poland syndrome range from subtle hypoplasia to aplasia of the breast (Fig. 9). Poland syndrome can affect both sexes [55–57]. Surgical procedures to correct breast asymmetry in adolescents must be delayed until breast development is complete [9].

Mammary ductal ectasia in the pubertal girl

Mammary duct ectasia is the dilatation of one or more mammary ducts. This condition can be a normal physiological variation during puberty due to transiently enlarged ducts as a consequence of epithelial cell desquamation producing an accumulation of secretions [32]. Ductal ectasia manifests usually as a non-tender palpable mass, and occasionally as a painful lump, or nipple discharge that can be bloody. The accumulation of secretions can produce epithelial ulceration with ductal inflammation and localized mastitis (Fig. 10) that can lead to an abscess. Ductal ectasia most commonly affects the subareolar ducts but can also involve the smaller peripheral ducts. In the presence of ductal ectasia, US shows a cluster of smooth-walled, anechoic, tubular or round structures typically in the retroareolar region that might interconnect. If infection is present, intraductal internal echoes representing debris, as well as stranding and indistinctness of the adjacent soft-tissue planes with hyperemia, are demonstrated (Fig. 10). Unless it is infected, at this age (Fig. 10) ductal ectasia should be treated through observation [4, 22, 45, 58, 59].

Fig. 10 A 10-year-old girl with infected ductal ectasia. **a** A clinical photograph shows erythema in the periareolar region of the right breast. **b** A grey-scale sagittal ultrasound image of the right breast shows cystic retroareolar structures (*arrow*) corresponding to dilated mammary ducts. Skin thickening, indistinctness and increased echogenicity of the surrounding breast parenchyma (*asterisks*) are visible. **c** A sagittal ultrasound image with color shows mild hyperemia surrounding the dilated ducts. **d** A transverse ultrasound image obtained after antibiotic treatment shows resolution of the periareolar inflammatory changes with improvement of the retroareolar duct dilatation (*arrows*)



Juvenile breast hypertrophy

Juvenile, virginal or adolescent breast hypertrophy is a spontaneous and progressive massive growth of the breasts that occurs during a short period of months, usually during puberty. It can be unilateral or bilateral and can occur at any time during the pubertal period. Histologically, this entity shares some features with gynecomastia, hence the name gynecomastoid breast hypertrophy. The etiology has been attributed to heightened response or increased sensitivity of breast tissue to estrogens. Girls with this condition often complain of psychological discomfort (embarrassment) and back pain. In some cases, it can be familial. US shows very prominent breasts with a large amount of stroma (Fig. 11). US is also very helpful in excluding an underlying mass or an infection in cases of unilateral involvement. Antiestrogenic drugs, such as tamoxifen, can be used to halt breast growth, but the majority of girls eventually undergo reduction mammoplasty once breast size has stabilized [4, 8, 12, 32, 60].

Fibrocystic changes

Fibrocystic changes refer to the microscopic features that characterize abnormalities seen in benign breast biopsies that do not represent a distinct macroscopic breast lesion. The histological changes include gross or microscopic cysts, apocrine metaplasia, fibrosis, blunt duct adenosis and minor degrees of sclerosing adenosis and usual epithelial hyperplasia. Fibrocystic changes are thought to be the result of an imbalance between estrogen and progesterone [61]. These changes occur commonly in women during the third decade of life and, although reported in adolescents, they are rare in those younger than 20 years old [4]. Due to the common occurrence of these findings in the female population, the term “fibrocystic disease” was abandoned several decades ago in favor of “fibrocystic changes.”

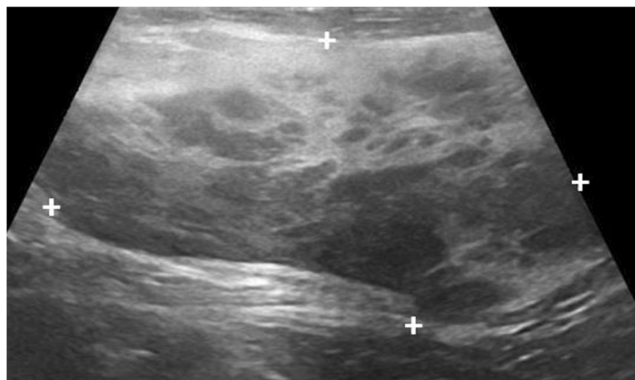


Fig. 11 An 11-year-old girl with biopsy-proven juvenile (virginal) breast hypertrophy. A panoramic grey-scale transverse ultrasound image of the right breast shows massive enlargement of the breast (*calipers*) with prominent hypoechoic fibroglandular tissue measuring up to 18 cm

Patients with fibrocystic changes present with cyclical premenstrual breast tenderness that improves during menses. On physical exams, the breast parenchyma is nodular with ridge-like areas of thickening upon palpation. Ultrasound features are nonspecific and include cysts of varying sizes, dilated ducts and fibrous echogenic tissue that may have associated posterior acoustic attenuation. The diagnosis is made with a detailed clinical history and physical examination and the absence of any other cause to explain the symptoms [4, 12, 61].

Conclusion

The breast has an identical histological composition in both sexes until puberty when it differentiates. Until puberty, the breast in both boys and girls undergoes transient changes triggered by physiological hormonal changes. It is important to be familiar with some basic endocrinological principles, such as perinatal hormonal changes and the so-called mini-puberty of infancy in early childhood, as well as with hormonal changes during puberty that can affect the clinical and imaging appearance of the developing breast in both sexes. In the pediatric population, US is the imaging modality of choice to evaluate the breast. Physiological changes of the developing breast can be unilateral, affect both sexes and can simulate pathology causing parental anxiety that could lead to unnecessary work-up. Furthermore, because primary breast malignancies are very rare in this population and invasive procedures can cause arrest of the breast bud development, any possible breast intervention should be carefully scrutinized.

Declarations

Conflicts of interest None

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