Breast abnormalities and disease are rare in the young developing breast. Malignancy is even more uncommon. Yet evaluation and management of breast disease in infants, children, and adolescents requires a conservative approach to preserve developing structures and cosmetic appearance. Diagnosing breast disease in young patients can be made more difficult by developing breast anatomy, which is denser than adult breasts. In addition, ordering physicians, radiologists, and radiologic technologists must carefully consider the use of ionizing radiation in the diagnosis and management of pediatric breast disease.

The types and presentation of breast abnormalities or masses in children and adolescents vary significantly from those found in adults. The vast majority of masses are benign, and many occur because of abnormal development in girls and boys. Malignancies found in pediatric breasts more often are metastatic rather than primary cancers.

Increased awareness of breast cancer has led to improved knowledge of and response to signs and symptoms of breast abnormalities; however, raised awareness also has likely intensified anxiety among patients and their family members when an abnormality appears in a child or adolescent. Regardless of age or sex, a finding of a mass in the breast causes concern. Physicians often recommend a conservative approach to diagnosing and managing breast complaints in children and adolescents because of the low incidence of malignant lesions, the need to preserve breast tissue, and concerns regarding the relative risk of radiation exposure to developing breasts. These concerns include rare to no use of mammography.

Most abnormalities of breast development can be investigated with medical history and clinical examination. Nevertheless, parental concerns, some practitioners’ inexperience or unfamiliarity with pathology, and concerns about patients’ breast development and body image can warrant careful investigation that includes diagnostic imaging or image guidance.

Diagnostic imaging of the breast usually is indicated for early detection of cancer or to rule out cancer. Breast malignancy is extremely rare in the pediatric population, but imaging often...
is used to ease parents’ minds. There are few clinical or radiologic findings that can help clinicians definitively diagnose breast disease in children and adolescents. However, ultrasonographic features often can help clinicians distinguish between benign and malignant lesions, and ultrasonography is the initial breast imaging study used for pediatric patients.

Mammography is not indicated in pediatric patients, largely because of its use of ionizing radiation and the dense, fibroglandular makeup of young girls’ breast tissue. Although mammography generally is not used to evaluate pediatric breasts, it can help assess microcalcifications or suspicious discrete masses in older adolescents. The risks associated with ionizing radiation generally make the use of computed tomography (CT) inappropriate for pediatric breast evaluation.

Magnetic resonance (MR) imaging might be appropriate for masses located in deep structures, such as along the chest wall. Dynamic contrast-enhanced MR has been investigated in adult breast and prostate cancer, but pediatric studies have been limited primarily to bone cancer. MR offers excellent tissue contrast, multiplanar capability, and uses no ionizing radiation. For these reasons, MR has been useful in evaluation of deep and large soft-tissue breast masses in children and adolescents and in helping to distinguish benign masses from malignant ones.

When early development is asymmetric, and particularly when it does not resolve as expected, ultrasonography can verify that the unilaterally developing breast consists of only normal breast tissue and can exclude an underlying mass as the cause. Ultrasonography is ideal for noninvasive confirmation of breast disease diagnosis in the pediatric population because the modality uses no ionizing radiation and can assist in identifying and characterizing most breast abnormalities. In addition, ultrasonography is useful for image-guided biopsies and as a safe follow-up imaging tool for children and adolescents with breast masses. The modality is readily available, relatively inexpensive, and adds to rapid initial assessment of breast abnormalities or palpable lesions.

Pediatric Breast Disease Incidence

The risk of developing breast cancer before 20 years of age is 1 in 15,000. Less than 1% of all breast cancer cases are diagnosed in patients who are aged younger than 25 years. Of all breast cancers, only 0.1% occur during childhood. A type of primary malignancy that arises in young breasts called a phyllodes tumor accounts for 0.5% of all breast tumors, and up to 8% of phyllodes tumors occur in women aged younger than 20 years. More phyllodes tumors occur in people of Asian heritage. Although some phyllodes tumors are malignant and their pathology demonstrates malignant behaviors, most phyllodes tumors in young women are benign.

The breast is an uncommon site for primary childhood cancer as well, accounting for fewer than 1% of childhood cancers. Most solid breast masses in female patients aged younger than 19 years are benign masses called fibroadenomas. Since the 1960s, as many as 50% of adolescent breast masses discussed in the medical literature have been fibroadenomas; between 44% and 94% of surgical articles on adolescent breast masses have been about fibroadenomas. Evaluation of pediatric breast masses often includes distinguishing phyllodes tumors from fibroadenomas.

Causes of Pediatric Breast Disease

Breast disease or abnormalities in infants, children, and adolescents tend to occur because of congenital or developmental conditions, other inherited or genetic factors, hormone imbalances, or for unknown reasons. Data from the Growing Up Today Study, which involved more than 6800 girls whose mothers participated in the Nurses’ Health Study, showed that girls and young women had a higher incidence of benign breast disease if their mothers or aunts had a history of breast cancer. The risk was particularly apparent for participants whose mothers and aunts had breast cancer that was diagnosed before 50 years of age.

A family history of breast cancer clearly has been shown to increase risk for benign breast disease in young relatives. The literature is somewhat sparse regarding the link between family history of breast cancer and juvenile breast malignancy, although some risk has been demonstrated. Having a first-degree relative with a history of breast cancer is a risk factor for malignancy in children or adolescents who have juvenile papillomatosis, a common, benign localized lesion in the breast.
Some rare cancer syndromes increase the likelihood that adolescents will develop multiple fibroadenomas. Examples are Mafucci syndrome and Cowden syndrome. Benign abnormalities also develop because of trauma, cyst formation, or infection.

Secondary malignancies occur as a result of metastatic spread from childhood cancers or previous exposure to radiation therapy for cancer treatment. Researchers continue to study possible reasons why rare lesions develop in the breasts of some young women and men.

Because malignancy in juvenile breasts is infrequent, and conservation of breast tissue is a priority, clinicians consider breast symptoms in children and adolescents seriously but with caution. A conservative approach to diagnosis and management of pediatric breast disease often involves monitoring a mass or abnormality with regular clinical breast examinations and follow-up using ultrasonography. When a diagnosis requires confirmation, fine-needle or core-needle biopsy is preferred to surgery. Solid lesions in children and adolescents are best evaluated by ultrasonography instead of biopsy when possible. Collecting specimens for biopsy from solid lesions, even with needles, causes breast trauma.

Medical Evaluation and History

The symptoms precipitating investigation of a breast abnormality in pediatric patients vary, and many symptoms can indicate benign and malignant conditions. Some patients have a bloody nipple discharge or serous nipple discharge. Younger patients with breast conditions often can have abnormal breast development or enlargement or asymmetric growth. Some patients experience pain and skin changes. Physicians might notice a palpable mass. Skin involvement such as distended veins, ulceration, or signs of inflammation also can raise concerns but is typical of fibroadenoma.

Newborn breast evaluation includes breast size assessment, evaluation of nipple position, and whether the infant has accessory nipples or discharge from the nipple. Doctors should evaluate breasts as part of a child’s or adolescent’s annual examination. Prepubertal girls should have an annual inspection and palpation of their chest wall to note masses or pain. Doctors also should look for signs of nipple discharge, premature thelarche, or abnormal development according to Tanner stages. Unilateral breast development at pubertal onset can continue up to 2 years before the contralateral breast becomes palpable, which can cause concern for patients, parents, and physicians.

Physicians generally examine adolescent girls with the patient in a supine position with the arm ipsilateral to the breast being examined placed next to the patient’s head. Physicians should palpate all breast tissue, check the sexual maturity rating according to the Tanner stages, and evaluate axillary, supraclavicular, and infraclavicular lymph nodes. Breast self-examination for teens generally is controversial because of the rarity of breast disease. In addition, normally developing breasts often appear asymmetrical and feel nodular.

In some cases, physicians can handle breast abnormalities by reassuring the patient and parents and by recommending continued observation. If symptoms worsen or growth continues, however, further investigation often is warranted. When diagnosing breast disease in children and adolescents, physicians consider how long the mass has been present and symptoms such as pain. They also consider whether the mass is unilateral or bilateral, how rapidly the mass is growing, and the patient’s family history of breast disease. A careful and complete medical and family history guide medical imaging management to evaluate young patients for breast abnormalities and potential malignancy.

Role of Genetics

Researchers have made some progress in identifying genetic markers for pediatric breast lesions and in linking the genetic basis of family history of breast cancer to benign breast disease in young relatives. In addition, researchers also are isolating more genetic markers for breast cancer in adults. CD117 and CD34 have been identified as growth factors in breast cancer progression, for example. Kaçar et al reported that adolescent fibroadenomas also have shown staining patterns for CD117 and CD34. The authors added that the markers are expressed differently in adolescents, however, which means adolescent breast tumors might develop differently or follow a tumorigenesis path that varies from adult breast malignancies.
Inherited mutations of the BRCA1 and BRCA2 genes are found in breast and ovarian cancers, and 15% of women younger than 30 years of age with breast adenocarcinoma have inherited BRCA mutations. Early-onset breast and ovarian cancers do not appear to have the same incidence of these mutations, and they do not appear to differ biologically from adult forms.\textsuperscript{15,16}

Mutation of the tumor suppressor gene \textit{p53} could be responsible for some early breast cancer. The mutation could be inherited as Li-Fraumeni syndrome. This autosomal dominant syndrome is extremely rare but is characterized by a predisposition to cancer evidenced by sarcomas and widespread tumors in children and young adults.\textsuperscript{17} Although fibroadenomas are benign masses, expressions of \textit{p53} protein have been found to be higher in fibroadenoma tissue than in samples of surrounding breast tissue.\textsuperscript{7} An association of \textit{p53} mutations and phyllodes breast tumors was described as early as 1994, and alterations in chromosome 17, which is the site of the \textit{p53} gene, have been noted in Mafucci syndrome. Mafucci syndrome has been associated with rare cases of malignant phyllodes tumors.\textsuperscript{13}

Genetic understanding of all disease is advancing rapidly and could eventually lead to improved genetic sequencing for people of all ages with breast disease and other illness. An example is breast cancer that over-expresses the \textit{ERBB2} (formerly \textit{HER2/neu}) protein. The cancer now can be treated much more effectively because of agents developed to target the \textit{ERBB2} protein specifically and halt its effects on promoting breast cancer cells.\textsuperscript{18} Even so, performing genetic testing or sequencing for girls who may have \textit{p53} germline mutations or many other identifiable genetic risk factors for breast disease is controversial and generally goes against clinical recommendations.\textsuperscript{13,16}

The National Comprehensive Cancer Network (NCCN) has developed and revised guidelines specifically for genetic and familial risk assessment in hereditary breast and ovarian cancer syndromes. These recommendations include guidelines for individuals with a history of early-onset breast cancer. The guidelines also include information on screening young women who have known risk factors such as Li-Fraumeni syndrome. The guidelines suggest that pediatricians be made aware of the risk of childhood cancers in families affected by hereditary syndromes and that physicians are able to interpret the information for potential follow-up and the effect of the results on treatment decision-making and patient outcome. In particular, the NCCN guidelines state that testing and disclosure of results be accompanied by genetic counseling.\textsuperscript{19}

Understanding the role of genetics in cancer and other diseases is a relatively young science. Targeted and individualized treatments have begun to change how oncologists treat cancer patients and could one day lead to patient-specific understanding of a child’s or adolescent’s risk for abnormal breast development and particularly for breast cancer risk.\textsuperscript{15,20}

**Breast Development**

**Early Breast Development**

Breast development begins in utero, between 4 and 5 weeks of gestation. Longitudinal ridges form along the anterior wall of the embryo’s ectoderm. The ridges stretch from the area on the embryo that develops into the axilla down to the primitive inguinal area, or groin. Each ridge is called a \textit{milk ridge} or \textit{milk line}. Breast tissue can develop anywhere along this line, but typically the lines above and below the pectoralis muscle recede as the embryo develops. The remaining tissue forms the mammary primordium, or primary mammary bud.\textsuperscript{5,8}

Between gestational weeks 10 and 16, lactiferous ducts develop from secondary buds that branch out from the primary mammary bud. The ducts become scattered throughout the developing mesenchyme, which gives rise to the breast’s fatty and fibrous tissues. The lactiferous ducts converge into a small opening that eventually forms the nipple. Development of the areola and nipple follows, and the areola can be seen around weeks 20 to 24. The nipple remains inverted. Maternal estrogen begins to influence breast development by the third trimester of pregnancy, which leads to formation of a true and palpable breast nodule, usually by 34 weeks of gestation. The nipple can be seen at birth but usually is depressed and advances soon after birth.\textsuperscript{5,8,11}

**Tanner Stages of Development**

Children who have not yet reached puberty have breast tissue comprising connective tissue stroma interspersed with epithelial-lined ducts. The breast tissue
of boys and girls is virtually identical until puberty begins. The next phase of breast development in girls begins with the onset of puberty, with breast development continuing for 2 to 4 years. The Tanner stages first were published in the 1960s to describe normal breast development in 5 phases. Pubertal hormones influence growth according to the Tanner stages. Specifically, estrogen continually stimulates growth of lactiferous ducts and fibrous and fatty tissue. Progesterone contributes to lobular tissue development and alveolar budding. The Tanner stages can be correlated with ultrasonography (see Figure 1) and histologic findings. See Box 1 for a brief description of Tanner stages.

Onset of Puberty and Thelarche

In general, normal breast development related to puberty, or thelarche, begins no sooner than 8 years (at a mean of 8.87 years for U.S. African Americans and 9.96 years for whites) and no later than age 13 years. The literature has reported a trend toward earlier onset of puberty and thelarche, particularly among American girls. The trend began early in the 20th century in industrialized nations, and the decline in age halted for several decades. Early puberty was again confirmed, however, in recent years. Breast development reportedly occurs between 1.5 and 2 years earlier than the traditional age recorded by many textbooks, which suggest an average age of 10.3 years for thelarche. Several studies lend clinical evidence to these reports. Evidence varies, however, on the causes of earlier onset of thelarche. Biro et al observed differences based on ethnicity and on body mass index. Several studies have reported that earlier thelarche is associated with an upward trend in body mass index among young girls and adolescents. In general, however, the guidelines for the onset of puberty and thelarche remain arbitrary and require further study.

Developmental and Congenital Abnormalities

Breast development does not always occur as it should. Some abnormalities in infants or adolescents arise from congenital or other developmental causes. Some normal variations in breast development resolve on their own. For example, inverted nipples are normal variations that often run in families and should be considered as pathology only if an infant is born with normal nipples that later invert. Early breast development can be noticeably asymmetric but normal and benign. Asymmetric appearance and other developmental abnormalities can mimic malignancy or raise concerns for patients, parents, and clinicians regarding breast appearance.

Because of the rarity of malignant breast lesions in children and adolescents and the potential for iatrogenic injury (inadvertent injury following surgery or other medical treatments and diagnostic examinations) to developing breasts, clinicians usually manage pediatric breast masses conservatively, with regular clinical and ultrasonographic monitoring. Surgical excision of breast masses in children and adolescents usually is reserved for symptomatic and rapidly growing masses. If surgery is indicated for a benign or malignant mass, surgeons consider cosmetic results and protection of developing breast anatomy such as the breast bud, nipple, and areola. Clinicians should involve parents in decision-making regarding management of pediatric breast problems.

Premature Thelarche

Because the timing of normal breast development is somewhat arbitrary and shifting, defining an age range for early breast development is likewise imprecise. Premature thelarche occurs when pubescent breast development begins in an African American girl before age 6 or in a white girl before age 7, or, in average terms, before 7.5 years old. Premature thelarche can begin as early as age 1 to 3 years and can occur in one or both breasts.

Ultrasoundography often is recommended as a non-invasive method for evaluating premature thelarche and determining that early breast growth is attributed to normal breast tissue when no discrete mass is observed. Clinicians must understand the appearance of pediatric breast tissue as it progresses through normal Tanner stages of development to compare with abnormal appearances from benign or malignant causes (see Figure 1 and Box 2).

Precocious puberty, or early puberty, can occur in young children and cause premature breast development.
Figure 1. The images demonstrate the 5 Tanner stages of normal pubertal breast development. A. Sonogram of Tanner stage I breast tissue in a 6-year-old girl shows a small area of ill-defined echogenic tissue in the retroareolar region (arrows). B. Sonogram of Tanner stage II breast tissue in a 13-year-old girl reveals an echogenic nodule (arrows) with a retroareolar, stellate, hypoechoic focus (*). C. Sonogram of Tanner stage III breast development in a 13-year-old girl demonstrates more echogenic, glandular tissue (arrow) with a central, spider-shaped hypoechoic focus (*). D. Sonogram of Tanner stage IV breast development in a 16-year-old girl shows more echogenic fibroglandular tissue (arrows) with a central hypoechoic nodule (*). Note also the increased subcutaneous fat anterior to the glandular tissue compared with earlier stages. E. Sonogram of mature (Tanner stage V) breast tissue in a 16-year-old girl demonstrates echogenic fibroglandular tissue (arrows) without a central hypoechoic focus. Reprinted with permission from Chung EM, Cube R, Hall GH, Gonzalez C, Stocker T, Glassman LM. Breast masses in children and adolescents: radiologic-pathologic correlation. Radiographics. 2009;29(3):909.
in young girls. Premature breast development can be the first sign of precocious puberty. The conditions do not always exist together, however. Fewer than 20% of cases of premature thelarche can be attributed to precocious puberty, which arises spontaneously. Precocious puberty most likely occurs when the hypothalamic gonadotropin-releasing hormone is activated prematurely. Precocious puberty usually is managed with reassurance and monitoring or follow-up. 

Premature thelarche is isolated from precocious puberty and is not caused by accelerated growth but likely is familial. Isolated studies have linked fetal exposure from maternal levels of certain pesticides as potential causes of premature thelarche and other early signs of puberty. Reasons for the general trend toward earlier puberty and thelarche remain ambiguous. Therefore, physicians must consider issues such as socioeconomic status, nutritional status, ethnicity, and genetic factors when determining whether thelarche is early or delayed in individual patients

Because management approaches for each condition differ, it is important to differentiate between precocious puberty and premature thelarche. Suspected precocious puberty should include radiologic bone age assessment. Pelvic and abdominal ultrasonography can complement hypothalamic gonadotropin-releasing hormone testing to distinguish premature thelarche from precocious puberty. Sonograms can demonstrate evidence of uterine and ovarian maturation or evidence of estrogen-producing lesions.

**Accessory or Absent Breast Tissue**

During breast development in utero, the milk line can persist rather than recede, causing accessory nipples to develop, an abnormality known as polythelia. Polythelia is relatively common, occurring in up to 2% of people. The abnormality usually is unilateral. Polythelia has been associated with some congenital abnormalities of the urinary and cardiovascular systems. A child also might develop multiple breasts, a condition known as polymastia. Polymastia can occur along with polythelia or independently of accessory nipples. Polymastia occurs in 1% to 6% of people and can be associated with renal abnormalities. Because polythelia and polymastia are associated with persistence of the milk line, extra tissue or nipples are typically found along the milk line but usually on the chest, upper abdomen, or in the axilla, slightly inferior to the normal breast. The amount of additional breast tissue varies from a minor amount to a fully formed breast.

Amastia, the absence or underdevelopment of the breast, is rare. The abnormality can be associated with other chest wall anomalies such as Poland syndrome. If a girl has small breasts but otherwise

---

**Box 1**

**Tanner Stages of Breast Development**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Prepubertal stage noted only by elevation of the breast papilla, or small projection similar to a nipple.</td>
</tr>
<tr>
<td>II</td>
<td>Enlargement and elevation of the entire breast becomes obvious. The subareolar bud is palpable but not elevated, and the areola becomes slightly pinker.</td>
</tr>
<tr>
<td>III</td>
<td>Volume of breast tissue increases, as does the size of the areola. There is no separation between the areola and breast contour.</td>
</tr>
<tr>
<td>IV</td>
<td>The areola and papilla begin to enlarge, mound, and project above the contour level of the breast.</td>
</tr>
<tr>
<td>V</td>
<td>Only the papilla projects as the areola recedes to become even with the breast’s mature contour.</td>
</tr>
</tbody>
</table>

**Box 2**

**Ultrasonography Characteristics of Tanner Stages of Breast Development**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Retroareolar tissue is hyperechoic and ill defined.</td>
</tr>
<tr>
<td>II</td>
<td>Small hyperechoic retroareolar nodule with simple branching ducts in linear or star pattern.</td>
</tr>
<tr>
<td>III</td>
<td>Hyperechoic gland tissue extending from retroareolar region. Central hyperechoic fingerlike region.</td>
</tr>
<tr>
<td>IV</td>
<td>Usually hyperechoic periareolar region. Noticeable hypoechoic nodule in the center. Some subcutaneous adipose tissue might be noted.</td>
</tr>
<tr>
<td>V</td>
<td>Increasing subcutaneous adipose tissue and presence of hyperechoic glandular tissue. Absence of hyperechoic central nodule.</td>
</tr>
</tbody>
</table>
normal pubertal development, the amastia is considered normal and requires no further investigation. If other pubertal development appears to be delayed, ovarian failure could be the cause of breast underdevelopment. Ovarian failure can be secondary to other disorders such as hypothyroidism. Amastia can be corrected surgically, but generally, surgery is not recommended to correct polymastia, polythelia, or mild asymmetry unless accessory tissue causes pain or cosmetic concerns warrant surgical intervention.

Hypertrophy

Up to 90% of male and female newborns can have transient hypertrophy of the breasts, or temporarily enlarged breast tissue. The condition is likely caused by excessive estrogen as the hormone passes across the placenta and sometimes is accompanied by a milky discharge from the infant’s nipple. Spontaneous hypertrophy in girls can occur during the second phase of breast development. Massive breast growth during puberty and adolescence might be caused by the breast's sensitivity to gonadal hormones. An adolescent who has juvenile hypertrophy might require reduction mammoplasty, but physicians recommend delaying the surgery until the late teen years to ensure complete breast development. Gynecomastia in adolescents usually regresses in 2 years or fewer.

Male breast tissue has receptors for estrogen and androgen. Estrogen stimulates breast tissue development, and androgens inhibit breast tissue proliferation. Most cases of gynecomastia are idiopathic, and the exact cause of pubertal gynecomastia is unknown, but gynecomastia can occur when estrogen and androgen become imbalanced. Many suspected causes of the condition, such as use of certain topical or oral medications, result in abnormal hormone reactions. For example, herbal and skin care products that contain lavender or tea tree oil could cause imbalance to estrogens and androgens.

More recent research points to leptin as playing a role in pubertal gynecomastia. Leptin is a peptide hormone found in mammary epithelial cells; its influence on activity in fatty tissue can lead to increased concentrations of estrogen. Pathologic causes include certain tumors and Klinefelter syndrome, which is the presence of an extra X chromosome in a male.

A diagnosis of gynecomastia often can be made based solely on clinical examination. At times, however, the diagnosis is uncertain, and imaging is advised. Mammography can assist in the diagnosis but is less effective if the patient has asymmetric nodular gynecomastia or when a cluster of subareolar ducts forms. The cluster can mimic a mass on a mammogram. In addition, some male patients are averse to having mammograms.

On sonograms, gynecomastia appears as areas of increased subareolar tissue, similar to early breast development. Often no mass is observed on sonograms of gynecomastia, but a mass is seen in up to 33% of cases. Dialani et al observed patterns of gynecomastia findings on sonograms. The authors found that lesions that are taller than they are wide and with microlobulations or an unusual lesion that is located...
outside of the retroareolar region increases suspicion of malignancy.\(^\text{31}\)

Newborn gynecomastia usually resolves on its own and requires no treatment.\(^\text{32}\) Gynecomastia associated with puberty typically can be managed with reassurance and education about the natural course of the condition or discontinuation of a drug that might be causing the condition.\(^\text{27,32}\) Surgery is seldom recommended for boys with gynecomastia.\(^\text{31}\)

**Cystic and Inflammatory Lesions**

Cystic disease of the breast is not common in children and adolescents, but occasionally a pediatric patient has a lesion associated with tenderness that is cystic or inflammatory.\(^\text{16}\) Often, obstruction of a duct or an infection is the cause of inflammation in a young breast.

**Galactocele**

Galactoceles are cystic masses made up of milky fluid. They usually appear only in lactating women, but they also can occur in male or female infants.\(^\text{7}\) The cystic masses can be unilateral or bilateral and are palpable.\(^\text{5,11}\) They typically form in infants or children because of stimulation from the hormone prolactin, ductal obstruction, or trauma that causes epithelial cell secretion.\(^\text{11}\)

Rajdev et al reported on a bilateral galactocele in an 11-month-old boy who had bilateral gynecomastia that had progressed for 8 months.\(^\text{35}\) Both breasts were Tanner stage III and on further examination felt cystic with a palpable nodule the size of a pea. The boy’s nipples expressed a white fluid. Ultrasonography and biopsy following surgical excision confirmed that the enlargement was caused by a bilateral galactocele.\(^\text{11}\)

Galactoceles can appear differently on sonograms depending on the amount of fluid they contain. The fluid portion appears hypoechogenic (gray), and the fat portion of a galactocele is hyperechogenic (appearing white). Because their makeup can vary, galactoceles can resemble complex cysts on sonograms.\(^\text{7}\) On MR images, only the galactocele’s wall and dividing membranes are enhanced.

Many galactoceles can be managed with monitoring by regular clinical or ultrasonographic examinations.\(^\text{11}\) Cyst aspiration might be required to provide a definitive diagnosis.\(^\text{2}\) Aspiration can relieve symptoms associated with galactoceles, and aspiration of a galactocele for diagnosis can serve as a therapeutic measure by draining the mass of its fluid component.\(^\text{2,11}\)

**Retroareolar Cyst**

Retroareolar cysts occur in adolescent girls. They are rare, and the incidence is unknown. Clinicians believe the cysts arise when the terminal channel that drains the Montgomery areolar tubercles becomes obstructed. The Montgomery tubercles are the raised structures on the surface of the areola that are made up of sebaceous glands and lactiferous structures.\(^\text{36}\)

When the small channels distend from obstruction, the resulting retroareolar cysts can cause inflammation. Sometimes there are no symptoms except for a palpable mass in the subareolar region.\(^\text{36}\) About two-thirds of patients have symptoms of inflammation, and the remainder have no pain.\(^\text{2}\) Inflamed and symptomatic retroareolar cysts also tend to have enhanced vascularity (see Figure 2).\(^\text{36}\)

Ultrasoundography characterizes retroareolar cysts better than other imaging modalities. Clinicians must distinguish a retroareolar cyst from a breast abscess. Asymptomatic cysts appear as single or multiple anechoic (black) masses that are round or lobular. Inflamed retroareolar cysts often are fluid-filled, contain echogenic debris, and have increased peripheral vascularity. Inflamed and symptomatic retroareolar cysts also tend to have enhanced vascularity (see Figure 2).\(^\text{36}\)

Symptomatic retroareolar cysts remain relatively benign and generally respond well to a course of oral antibiotics and nonsteroidal anti-inflammatory drugs. An inflammatory cyst rarely will progress to an abscess. In general, inflammation from nonsymptomatic inflammatory cysts in the retroareolar region resolves without intervention in approximately 7 days. Long-term follow-up with ultrasonography typically shows that the cyst eventually regresses or completely dissolves.\(^\text{36}\)

**Mammary Duct Ectasia**

Infants and young children can have a bloody nipple discharge related to mammary duct ectasia.
The condition usually involves the retroareolar ducts and might result from malformation of the ducts.\textsuperscript{2,4} Sometimes, palpable masses are present that may or may not be tender. If the secretions in the ducts back up, the infant can develop a bacterial infection. \textit{Staphylococcus aureus} or \textit{Bacteroides} species infections are known to occur in patients who have mammary duct ectasia.\textsuperscript{2}

This condition also occurs infrequently in female adolescents. The patient can have inflammation caused by periductal mastitis, along with nipple discharge and breast pain that is not associated with menstrual cycles. The nipple can retract, or an abscess might appear in the subareolar region.\textsuperscript{5}

Ultrasonography can be useful in diagnosing the cause of bloody nipple discharge in infants, which is often attributed to mammary duct ectasia. Dilated ducts are a common but not consistent finding, and other findings on sonograms can vary.\textsuperscript{9} In adolescents, mammary duct ectasia appears on ultrasonography as debris-filled ducts or as tubular anechoic lesions. Ultrasonography also might be helpful in monitoring mammary duct ectasia as part of an expectant management, or watchful waiting, approach. When the ectasia is localized, breast ductography might be more useful than ultrasonography.\textsuperscript{4}

Bloody nipple discharge from mammary duct ectasia in infants often can be managed with watchful waiting. Most cases of bloody nipple discharge in infants resolve on their own within 11 months.\textsuperscript{29} In adolescents, antistaphylococcal antibiotics are used for obvious infections or positive cultures. Excision rarely is required because mammary duct ectasia usually resolves in adolescents and, in many cases, can be managed with watchful waiting that includes serial breast examinations and ultrasonography. Localized disease might require ductography and focal area excision if the patient experiences persistent or recurrent drainage.\textsuperscript{2,5}

\textbf{Mastitis and Other Infectious Lesions}

Mastitis is considered a disease of lactating mothers, but infants and adolescent boys and girls can have inflamed and infected mammary glands.\textsuperscript{2,11} Within the pediatric population, mastitis most often occurs in infants younger than 2 months and children between age 8 and 17 years.\textsuperscript{11} Mammary duct ectasia can be the underlying cause of mastitis, but cellulitis (skin infection), nipple injury, or a patient’s immunocompromised status also can lead to infection.\textsuperscript{2} Piercings can cause skin infections or nipple injury in adolescents, for example.\textsuperscript{11} In neonates, pathogens along the mucous membrane and skin can enter breast tissue that is temporarily stimulated by hormones through the nipple or ducts.\textsuperscript{11}

Mastitis is characterized by erythema, warmth, and tenderness in the infected area of the breast.\textsuperscript{11} If mastitis is not treated aggressively, an abscess can form.\textsuperscript{8} A breast abscess is characterized by a tender, firm mass and erythema. The mass can extend from the nipple to the breast’s upper inner quadrant and can be movable and compressible.\textsuperscript{7} Panteli et al reported that previous studies and the authors’ retrospective review of girls

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Figure2.png}
\end{figure}
who had been treated as infants for neonatal mastitis and breast abscess showed a potential for abnormal breast development.³⁷ Follow-up ultrasonography and clinical examination demonstrated developmental problems at puberty such as scarring, breast asymmetry, and decreased breast tissue on the affected side in some girls who had been treated for neonatal mastitis.³⁷

*Staphylococcus aureus* is the most common infective agent in inflammatory breast lesions, accounting for at least 75% of mastitis cases.³⁸,³⁹ Other common pathogens associated with mastitis and abscesses include gram-negative bacilli, group A *Streptococcus* species, and *Enterococcus* species.¹¹ However, non–multiresistant methicillin-resistant *S aureus* (MRSA) is becoming increasingly common as a cause of infective mastitis. Montalto and Liu reported on a case of infant and mother infection from non–multiresistant MRSA causing breast abscesses.³⁸ The authors reported that the infant and mother most likely contracted the infections in the hospital following delivery. Further, the authors stated that because recent hospitalization is a risk factor for MRSA infection, all women who have been hospitalized for delivery also are at risk. Transmission of MRSA from mother to infant also is possible, although no cases of MRSA transmission from mother to infant have been reported.³⁸

Use of ultrasonography can assist clinicians in distinguishing mastitis from an abscess. Mastitis can appear as decreased or increased echogenicity, depending on whether it is in its early, acute stage or whether there is edema of the fatty tissue, which increases echogenicity.¹¹ Abscesses appear on sonograms as hypoechoic complex masses with thick walls. On color Doppler, vascular flow is seen only on the periphery of the mass. Ultrasonography also can be used to guide needle aspiration of abscesses.²

Breast infections are treated initially with antibiotics and analgesics.⁸ Although the literature is limited on specifics regarding long-term effects of infant mastitis, some girls who have had incisions and drainage for abscesses have had scarring and breast asymmetry years later.³⁹ As a result, prompt parenteral antibiotic treatment is preferred for neonates to prevent abscess formation.³⁸,⁹ Adolescents can be treated with oral antibiotics and warm compresses for mastitis.⁸ Necessary surgical evaluation and drainage of breast abscesses in pediatric patients should be performed with ultrasonographic guidance.⁹

**Hematoma and Injuries**

Common causes of hematomas are trauma or iatrogenic trauma.² Adolescents breast trauma often is caused by contact sports.⁴ Children and adolescents can injure their breasts by falling, being kicked, or being hit in the breast by elbows or sports equipment.⁴⁰ When a contusion or hematoma forms on the breast, it might resolve on its own or lead to fibrocystic changes and retraction of the skin or nipple over the injured area.⁷ Breast hematomas also can lead to abscesses or result in thrombophlebitis or fat necrosis.⁴⁰

Pediatric physicians are more concerned about blows to the head, face, and neck, but children also can experience trauma to the breast area, especially when participating in sports. The American Academy of Pediatrics has reported that thousands of boys and girls younger than age 19 years throughout North America participate in boxing. Although data are limited, Canadian hospitals reported that 7% of boxing-related injuries among children and adults between 1990 and 2007 consisted of bruises or abrasions to the soft tissue of the trunk.⁴¹

A hematoma appears as a complex cystic mass on a sonogram. The internal echotexture of a hematoma varies depending on the age of the injury. Acute hematomas generally are hyperechoic and become progressively anechoic with healing. On a mammogram, a hematoma appears as a mass with architectural distortion.²

**Fibrocystic Changes**

Although most cysts in adolescent girls occur in the nipple and areolar region, palpable cysts can form in other areas of the breast in children and adolescents. Multiple uninfected cysts can form, although solitary cysts are more common.²,⁸ Studies have identified histologic patterns called fibrocystic changes, some of which can increase later risk for breast cancer.² Fibrocystic changes are not the same as fibroadenomas, which are more common benign lesions.⁷

Fibrocystic changes include several types of changes in tissue structure and organization. Fibrosis, or fibrous mastopathy, is a solid white mass that can surround
terminal ductal-lobular units. Other fibrocystic changes, such as atypical ductal hyperplasia and mammary dysplasia, are extremely rare in children and adults but can occur in late adolescence and develop later into breast cancer.⁵,⁶

Fibrocystic changes are not specific on sonograms. Multiple cysts usually are noted, and the cysts vary in size. Dilated ducts also are found with fibrocystic changes, as are focal echogenic areas.²

**Benign Masses**

Several types of benign masses can arise in otherwise normal pediatric breast tissue. Benign lesions are up to 100 times more common in children and adolescents than malignant lesions⁴; therefore, appropriate clinical, diagnostic imaging, and, at times, histological investigation often are important in the pediatric population. Some of these masses have benign characteristics but neoplastic processes.¹¹ The most common benign masses among this age group are fibroadenomas.

**Fibroadenomas**

Fibroadenomas are caused by overgrowth of the breast lobule’s connective tissue called *stroma*, but the benign masses can comprise both connective and epithelial tissue.¹¹,⁴² The masses grow slowly, can be large or microscopic, and can be singular or multiple in nature.²,⁷ Fibroadenomas typically are palpable and feel rubbery, smooth, and mobile.²,⁷ The typical size of a fibroadenoma is 2 cm to 3 cm.⁵ Most occur in the upper outer quadrant of the breast.²¹

More than 90% of solid masses in the breasts of girls younger than age 19 years are fibroadenomas.¹¹ On average, they are more likely to occur in adolescents between ages 15 and 17 years and rarely are seen before a child reaches puberty.²,¹¹ Incidence is reported to be slightly higher in African American girls than in white girls.⁸ Fibroadenomas have been reported in a few boys, but they seldom occur because boys have no terminal ductal lobular units.¹

Shi et al reported on a unilateral fibroadenoma in a 16-month-old girl.⁴² The infant had a 6-month history of progressive unilateral breast enlargement. The child’s birth had been normal and her development was otherwise normal, but her grandmother had a history of breast cancer. Using ultrasonography, a solid mass measuring 3 cm was found on the upper outer quadrant of the enlarged breast (see Figure 3). The infant’s progesterone, testosterone, and luteinizing hormone levels were slightly below normal ranges, but other hormone levels were within normal ranges.⁴²

A mammogram showed that the mass was spherical and solid with a well-defined border and no microcalcifications or lymph node swelling. MR imaging showed that the mass had smooth borders but nonuniform tissue, along with a triangular shape (see Figure 4). Physicians initially diagnosed fibroadenoma and cystosarcoma, but histology following fine-needle aspiration confirmed only fibroadenoma cells.⁴²

Most child and adolescent fibroadenomas are typical or simple types. More complex types have characteristics such as epithelial calcifications, localized cysts, and sclerosing adenosis. They also might have multiple nodules, fibrous tissue, and small cysts. Complex fibroadenomas are associated with a higher risk of breast cancer within 20 years of mass removal than are typical fibroadenomas, but these are more common in older patients. Patients usually have no pain or other complaints with fibroadenomas. Rarely, a fibroadenoma causes bloody discharge from the patient’s nipple.

Fibroadenomas likely develop as abnormal responses to estrogen stimulation. They can grow more rapidly during pregnancy but appear to be unaffected by fluctuations in hormones related to menstrual cycles. On pathologic examination, fibroadenomas are smooth or mildly lobulated and well circumscribed.

A subtype of adenoma called juvenile or giant fibroadenoma makes up less than 4% of all fibroadenomas. This type occurs more often in African American female adolescents than in other girls. Giant fibroadenomas occur infrequently, and when they occur, they usually develop in adolescent girls. They grow even more massively than most fibroadenomas and cause a girl’s breast to enlarge much more rapidly than it would from normal development. Typically, a fibroadenoma is defined as giant if it weighs more than 500 g, is 5 cm to 10 cm in diameter, or if the mass replaces at least four-fifths of the patient’s breast. Most are cellular types and can be accompanied by physical signs such as prominent skin ulceration and dilated superficial veins over the mass.

On pathologic examination, giant fibroadenomas usually are multilobulated or marked by small bulges on their surfaces. Some are marked by small cysts and depressions. They are difficult to distinguish from malignant phyllodes tumors until examined more closely, often by imaging or aspiration biopsy.

A benign tumor called tubular adenoma is related to fibroadenoma and is considered a variant of fibroadenoma by some authors. This extremely rare mass is distinguished from fibroadenoma by its uniform composition and tightly constructed tubular or acinar epithelial makeup scattered with connective tissue.

Ultrasonography is sensitive for detecting and assessing fibroadenomas, which are relatively easy to distinguish from many other benign breast lesions in children and adolescents. Fibroadenomas typically are reported as isoechoic or hypoechoic solid and fairly uniform lesions. They also can appear as slightly anechoic with low-level internal echoes. Giant fibroadenomas often have the appearance of fluid-filled clefts. With use of color Doppler, fibroadenomas typically are avascular or have limited central vascularity.

A fibroadenoma is well defined, round or oval, and macrolobulated on a mammogram. Fibroadenomas might be associated with calcifications on mammography, which appear as small peripheral densities that gather in popcornlike calcifications. Although CT scans are not recommended to evaluate pediatric breast masses, fibroadenomas are common enough to be reported as incidental findings in CT scans for other indications. On CT, a fibroadenoma is noted as a round, smoothly lobulated, or ovoid mass that is well demarcated and has no calcification.2

On MR, fibroadenomas vary in appearance. Reports have shown that the benign masses demonstrate T2 enhancement and hyperintensity slightly more often than they demonstrate T2 signal intensity and no enhancement. Some show septations and low signal intensity on T1 weighting. With intravenous contrast agent enhancement, fibroadenomas generally demonstrate benign characteristics by enhancing slowly and demonstrating delayed washout. Nevertheless, the literature reports difficulty distinguishing fibroadenomas from phyllodes tumors on MR images.2

In many cases, an adolescent’s fibroadenoma can be monitored for 2 menstrual cycles or longer to ensure there is no change in the mass other than regression.6 These benign masses tend to grow slowly and eventually regress.2 Watchful waiting with serial ultrasonography is the typical course of action. Fibroadenomas that enlarge should be evaluated with fine-needle aspiration or excision, particularly if the mass becomes larger than 5 cm.6 Giant fibroadenomas often require excision because of their rapid growth.2

**Papillomas**

Papillomas are breast lesions that resemble papillae, or small nipplelike or wartlike projections. Adult women, usually aged 30 to 50 years, can have papillomas, but juvenile papillomatosis occurs most often in women aged younger than 30 years.16,43 The term papillomatosis describes microscopic focal papillary lesions that arise from abnormal amounts of ductal cells projecting into the ductal lumen, or cavity.5,43 The masses vary in size from 1 cm to 8 cm, usually are uniform, or without atypia, and often are confused with fibroadenoma.2,11,43 The masses usually are noted by a number of cysts and dilated ducts within dense areas of connective tissue (see Figure 5).11

Figure 5. Sonogram of a 14-year-old girl with juvenile papillomatosis. Patient presented with complaint of new soft palpable mass in upper inner quadrant of right breast. Initial diagnostic ultrasound shows oval-shaped mass (arrow) that is parallel in orientation, measuring 4.9 × 2.8 cm, at 1 o’clock radius, 3 cm from nipple, in right breast. Mass is of mixed echogenicity with both solid and cystic components. Patient returned for ultrasound-guided core needle biopsy and surgical consultation. Pathologic analysis of core needle biopsy showed juvenile papillomatosis without atypia. Right breast lumpectomy with wide margins was performed, with surgical pathologic analysis also showing extensive juvenile papillomatosis without atypia. Close clinical follow-up by breast surgeon was recommended because of slightly elevated risk of breast cancer associated with this lesion. Reprinted with permission from Kaneda HJ, Mack J, Kasales CJ, Schetter S. Pediatric and adolescent breast masses: a review of pathophysiology, imaging, diagnosis, and treatment. AJR Am J Roentgenol. 2013;200(2):W211.

Localized masses can occur in older adolescents and young women who have juvenile papillomatosis.2 Patients usually have masses in multiple ducts but typically report no pain from the lesions.5,43 Although juvenile papillomatosis is a uniformly benign condition in adolescents,2 it is associated with increased risk of later breast cancer in some patients and their female relatives. In particular, adolescent girls who have bilateral juvenile papillomatosis and a family history of breast cancer are at increased risk for developing breast cancer later.43 Recurrence of benign papillomas also has been reported.5

Sanguinetti et al reported on a rare case of juvenile papillomatosis in an adolescent boy.23 A literature review by the authors revealed only 4 cases of the disease in boys, and all were older than 11 years of age. The authors’ patient was aged 17 years; he had
a 2- to 3-month history of nipple discharge that was bloody and intermittent. The patient also presented with a mass in the upper outer quadrant of his right breast that was growing slowly. The mass was firm and localized to subcutaneous tissue.

The mass was easily removed by surgery and examined. It contained multiple small fluid-filled cysts. The mass also was associated with ductal ectasia and other clinical variants that have not been described before in young men.6

Intraductal papillomas are tumors of mammary ducts that seldom occur in children and are particularly rare in boys. Solitary intraductal papillomas infiltrate major lactiferous ducts and are a common finding among women aged 30 to 50 years who have nipple discharge. Intraductal papillomas also can occur bilaterally and can be similar in histology to juvenile papillomas.2,4

Juvenile papillomatosis appears on sonograms as a poorly defined mass with variable internal echoes. Multiple small cysts, characterized by one or more small circles of nearly echo-free areas, usually are apparent, especially near the lesion’s periphery.2,5 Microcalcifications might be apparent on a sonogram and on mammograms. Mammograms also might show asymmetric density but be otherwise negative. On MR, T2 weighting best demonstrates the marked enhancement of juvenile papillomatosis lesions. The mass will be lobulated in appearance and show small internal cysts.2

Surveillance for patients with juvenile papillomatosis is recommended because of the condition’s association with breast cancer. Juvenile papillomatosis usually is managed with surgical resection of the affected breast and preservation of the normal breast.2

Vascular Lesions

Although vascular lesions represent malignant activity in adult breasts, they typically are benign in children and teens. Vascular malformations are not accompanied by masses. Hemangiomas are hamartomatous tumors, resembling natural breast tissue. Some grow rapidly and others grow slowly. They seldom are seen in pediatric patients.8 When hemangiomas or vascular lesions form in children, they more often involve the chest wall than the breast.2

A hemangioma that occurs in infancy called capillary or infantile hemangioma is a common type of infant neoplasm. This type of hemangioma occurs during the infant’s first months of life and can continue growing until age 11 to 12 months. At this point, the hemangioma might begin an involution that lasts for several years. If the hemangioma involves the overlying skin, the skin will appear red and highly pigmented (ie, a strawberry nevus appearance).1

Hemangiomas can be distinguished from vascular malformations on sonograms by the hemangioma’s appearance as a superficial, discrete parenchymal mass. The border of a hemangioma often is distinct, which helps to distinguish the mass that can be either hyper- or hypoechoic in relation to normal surrounding breast tissue. Sonograms also display vascular channels near the center or periphery of the hemangioma.2

Other Benign Lesions

A granular cell tumor, or myoblastoma, often arises from skin or tongue tissue. Approximately 5% of myoblastomas arise from breast tissue; still fewer occur in children. Myoblastomas make up less than 1% of all childhood breast tumors. The masses are palpable and firm and can cause skin retraction. Physicians once believed that the masses originated in muscle cells but now believe they develop in perineural cells.2

A granular cell tumor varies in ultrasonographic appearance and can be difficult to distinguish from malignant lesions. Sonograms typically show poorly defined masses that are solid with posterior acoustic shadowing. Some granular cell tumors are circumscribed and have posterior acoustic enhancement, and there have been reports of these tumors displaying rapid peripheral enhancement, which usually suggests malignancy. Many granular cell tumors have a hyperechoic rim.2

Mammography characteristics of granular cell tumors vary from round, well-demarcated lesions to masses with spiculated margins similar to carcinomas. T1-weighted MR images of granular cell tumors have demonstrated a mass that enhances uniformly following intravenous contrast agent administration.2

A condition called pseudoangiomatous stromal hyperplasia (PASH) usually occurs in premenopausal women but has been reported in young women in their late teens.
The tumors are interconnected focal areas of proliferating breast stroma. Spaces in the tumors are lined by myofibroblasts, which appear similar to the cells from which muscle tissue forms. PASH can appear similar to fibroadenoma. PASH masses are firm, rubbery, mobile, and painless. They can grow rapidly in adolescents.2,11

PASH appearance varies markedly on sonograms. These masses often are reported as solid, circumscribed, and hypoechoic. The masses usually are parallel to the chest wall and resemble fibroadenomas.2 PASH masses often are treated with simple surgical excision. PASH has a reportedly high recurrence rate compared with other benign breast lesions.2

**Malignancies**

Very few primary breast cancers occur in pediatric patients. Of the cases that occur each year, the average age of patients is 11 years and the majority of patients are girls.3 Many practitioners are unfamiliar with the various subtypes of benign and malignant conditions that cause breast masses or other abnormalities in infants, children, and teens.4,13 Further, the rarity of breast cancer incidence in pediatric patients, along with the infrequency of breast cancer subtypes found in this population, limits much of the research and literature to case reports and smaller population-based studies.8,44

An overlap of benign, intermediate (borderline malignant), and malignant characteristics of some tumors complicates clinical approaches to pediatric breast disease.2,5 A study of 37 female adolescents with breast lesions revealed evidence of ductal carcinoma in situ within fibroadenomas of 2 of the girls.4 Although breast masses in children and adolescents remain overwhelmingly benign, some tumors are classified as benign but as markers for familial breast cancer. These tumors, such as juvenile papillomatosis, can lead to cancer later in life, recur locally, and even metastasize.2,5

In addition, the literature reports that a number of carcinomas and phyllodes tumors have been misdiagnosed as benign fibroadenomas in children before surgery.4,12 An understanding of benign and malignant types that rarely occur, along with their differences and similarities, can help practitioners better assess and manage pediatric breast abnormalities.

**Phyllodes Tumors**

Phyllodes tumors, commonly known as *cystosarcoma phyllodes*, are structurally similar to fibroadenomas and display a variety of clinical behaviors.4,5 Phyllodes tumors make up only 0.3% to 1% of all breast neoplasms arising from cells of the fibrous epithelial tissue,5 for an incidence rate of approximately 2.1 per 1 million women.13 Even so, phyllodes tumors are the most common primary breast malignancy in children and adolescents. Up to 8% of all phyllodes tumors are found in female patients aged younger than 20 years.13

Phyllodes tumors grow rapidly and generally present as a painless, mobile, and rubbery mass.2,11 Masses found in pediatric patients generally are about 6 cm or larger at the time of diagnosis.2 Their clinical and pathologic characteristics vary greatly, and there is no single disease entity.6 They are made up of more stromal cells than are fibroadenomas and often display a leaflike pattern histologically. Some phyllodes tumors might be fibroadenomas that have undergone mutation that results in their consisting solely of stromal cells.7 Most importantly, the biological characteristics of phyllodes tumors in adolescents appear to be distinctly different from those found in adult women.8

Depending on several histologic features, phyllodes tumors are classified as benign, intermediate, or malignant, but the tumor’s behavior in adolescents does not always match its histologic features.7,13 In general, malignant phyllodes tumors have characteristics such as infiltrative margins and stromal overgrowth, but clinicians also consider mitotic activity and nuclear atypia to determine whether phyllodes tumors are benign or malignant.11,46

Certain genetic features, such as expression of CD117 in fibroblast cells, might be associated with phyllodes tumors’ potential for malignancy.4 Phyllodes tumors in adolescents have been reported to have a malignancy rate of approximately 13% to 15%.13 Deaths have been reported in adolescents with phyllodes tumors, but studies have shown that the malignancy is no more aggressive in adolescents than in older women.4,13

On ultrasonography, phyllodes tumors appear similar to fibroadenomas.2 Phyllodes tumors usually are well defined and have smooth margins. The masses tend to
appear as oval or lobulated and can contain fluid-filled peripheral cysts. The internal echotexture of phyllodes tumors usually is not uniform, which helps to differentiate these malignant masses from many benign fibroadenomas. Phyllodes tumors can have anechoic cysts or clefts, which distinguishes them from fibroadenomas but not from giant fibroadenomas.

On a mammogram, phyllodes tumors have no calcifications and usually appear as large, nonspecific masses. On MR images, phyllodes tumors usually are well-circumscribed round or lobulated masses. Their signal intensity varies on T2 weighting, and they can be hypointense or isointense compared with normal breast tissue on T1-weighted images. The contrast enhancement pattern of a phyllodes tumor is suspicious for malignancy but similar to that of a fibroadenoma. On diffusion-weighted images, tumors that have a low apparent diffusion coefficient are more likely to have malignant features of stromal hypercellularity. An MR finding of irregular cyst walls indicates necrosis and has been associated only with malignant phyllodes tumors. However, MR imaging alone is not sufficient to differentially diagnose phyllodes tumors from benign lesions.

Suspicious findings on imaging or progressive growth indicates a need for cytologic or histologic examination. Overall prognosis for children and adolescents with malignant phyllodes tumors is more favorable than for adults with these malignant tumors. Local recurrence occurs in up to 20% of patients, and distant recurrence is reported in 5% to 10% of patients. Most recurrences are from those tumors that have infiltrative borders or positive surgical margins.

Typically, phyllodes tumors should be excised with a 1-cm margin. Re-excision might be required if margins are inadequate or in cases of local recurrence. Adjuvant therapy has a limited role for phyllodes tumors in the pediatric population; however, adjuvant radiation therapy might be appropriate if a surgeon cannot remove an adequate tumor margin along the chest wall. Physicians should closely monitor young patients who have malignant phyllodes tumors.

Carcinoma

Incidence of carcinoma in patients younger than 20 years old is approximately 0.03 cases per 100 000. Adenocarcinoma of the breast is extremely rare, accounting for less than 1% of all breast masses in children. The appearance of adenocarcinomas on sonograms varies. Adenocarcinoma often is described as a hypoechoic mass with nonuniform internal echoes and irregular margins. The masses also are characterized by variable acoustic shadowing.

The most common subtype of breast carcinoma among children and adolescents is secretory carcinoma. This subtype was first described as juvenile carcinoma because it was believed to occur only in children. Secretory carcinoma seldom spreads regionally or distantly but can recur locally.

Secretory carcinomas in children and adolescents usually are firm, painless, progressively growing masses. Most masses are less than 3 cm in diameter, and the largest size reported is 16 cm. Breast carcinoma in pediatric patients can be associated with BRCA1 and BRCA2 mutations.

Breast carcinoma is exceptionally rare in boys, but Kavalakat et al reported on a case of secretory carcinoma in a boy aged 17 years. When the patient arrived at the hospital, he had swelling of the right breast and a history of a previous excision of a lump. The patient experienced swelling in the subareolar region of the same breast 2 years prior to this hospital visit. At that time he was found to have a benign epithelial proliferative lesion based on another hospital’s fine-needle aspiration cytology.

Based on histology of the previous lumpectomy specimen, the mass was diagnosed as invasive lobular carcinoma. Although the boy was referred to an oncologist for treatment including mastectomy, he instead chose herbal therapy. He experienced local recurrence of the mass within 6 months of the initial visit, prompting follow-up with an oncologist and initiation of chemotherapy. The patient did not regularly attend chemotherapy treatment and discontinued therapy.

At examination by Kavalakat et al, a 5 × 4 cm tumor that had infiltrated the skin was present in the right breast’s subareolar region (see Figure 6). Multiple nodules around the main tumor were observed and multiple ipsilateral axillary lymph nodes were involved, but there was no evidence of metastasis. The tumor was diagnosed as secretory carcinoma of the breast, and
the boy underwent a modified radical mastectomy and postoperative radiation therapy.\textsuperscript{47}

Secretory carcinomas appear on sonograms as single microlobulated, hypoechoic masses that resemble fibroadenomas and other benign lesions or well-circumscribed carcinomas. The mass often has a hypoechoic or isoechoic internal echotexture.\textsuperscript{48} The masses usually appear as round or oval.\textsuperscript{11}

Secretory carcinomas generally are less aggressive in children than in adults, and children who have tumors smaller than 2 cm that have circumscribed margins should have a good prognosis. Management for children usually includes local excision and either sentinel lymph node biopsy or complete axillary node dissection. Adjuvant therapy usually is not recommended.\textsuperscript{48} Rare subtypes of breast carcinoma represent a poor prognosis in pediatric patients.\textsuperscript{2} Physicians generally consider any enlarging breast mass a concern in a young patient with a known malignancy, regardless of the lesion’s characteristics on a sonogram.\textsuperscript{7} Confirmation of a diagnosis such as secretory breast carcinoma is made possible with fine-needle or core-needle biopsy to determine specific histology.\textsuperscript{48}

**Angiosarcoma**

This rare type of breast tumor in adult women can occur as a secondary malignancy in adolescents. It has been reported in patients who were treated previously for breast cancer and Hodgkin disease. Patients have a painless mass and skin discoloration. The majority of angiosarcomas are of histologically low grade and contain a network of vascular channels. High-grade angiosarcomas also can have papillary formations, mitoses, necroses, and other findings.\textsuperscript{2}

Radiation treatment for Hodgkin disease in girls aged between 10 and 16 years is a known risk factor for subsequent breast cancer within the radiation field and increases with the number of years following treatment. These secondary breast cancers typically do not occur before 25 years of age.\textsuperscript{11}

Angiosarcoma features vary on sonograms. Although approximately one-half of the malignant breast lesions appear as hypoechoic, there are reports of hyperechoic and mixed lesions. Angiosarcomas rarely display posterior enhancement and do not have posterior acoustic shadowing. On color Doppler images, angiosarcomas are hypervascular. Approximately 30% of angiosarcomas are occult on mammograms. Those that are visible on a mammogram appear as focal asymmetry and can be a single mass or multiple noncalcified masses. MR imaging shows large, lobular nonuniform masses. On T1 weighting, angiosarcomas are hypointense; they are hyperintense on T2-weighted images. On contrast-enhanced MR, angiosarcomas show typical wash-out patterns and rapid initial contrast enhancement associated with malignancy.\textsuperscript{2}

**Metastases**

Breast malignancies in children and adolescents most often are metastatic lesions secondary to another cancer.\textsuperscript{3,5} Breast metastases are more common in girls and rarely occur in boys.\textsuperscript{2} Lymphoma, leukemia, neuroblastoma, melanoma, Ewing sarcoma, renal cell carcinoma, and rhabdomyosarcoma are known primary cancers in children that result in breast malignancy.\textsuperscript{3,5} A breast tumor in an adolescent with a history of childhood acute lymphoblastic leukemia might be the first indication of disease relapse.\textsuperscript{4} Rhabdomyosarcoma is among the most common primary tumor to metastasize to juvenile breasts.\textsuperscript{2}
Rhabdomyosarcoma makes up 12% of childhood solid tumors and 40% of all soft tissue sarcomas. Occurrence of rhabdomyosarcoma in the breast is extremely rare, usually confined to adolescent girls, and often metastatic. Most primary rhabdomyosarcomas that metastasize to the breast originate in the trunk, neck, extremities, or orbit. The literature includes reports of rare metastatic breast rhabdomyosarcomas and how to diagnose or manage the masses. These metastatic lesions can be confused with benign fibroadenomas.

Jung et al reported on an 18-year-old female patient who had a one-week history of a palpable mass in the left breast and a past medical history of acute lymphoblastic leukemia and anal rhabdomyosarcoma. No evidence of distant metastasis had been observed one year earlier upon diagnosis of the anal rhabdomyosarcoma. The patient had received chemotherapy, and fludeoxyglucose-18 positron emission tomography–computed tomography did not show remission at the primary tumor site. The patient's breast mass was firm, round, and painless. It measured $3 \times 3$ cm.

Karplus et al reported on a study of nonrhabdomyosarcoma soft-tissue sarcomas, which represent 4% of all childhood malignancies. In the United States, these cancers are diagnosed in 500 children and adolescents each year. The authors reported that nonrhabdomyosarcoma soft-tissue sarcomas are seldom seen in the axilla and groin but are accompanied by high risk for metastasis when found in these areas. A female adolescent in the study who had nonrhabdomyosarcoma soft-tissue sarcoma in the groin died of metastatic breast cancer 12 years following diagnosis.

Although metastatic breast lesions can be multiple and bilateral, they often are large solitary masses. They can be painful but sometimes are painless. Many are mobile and enlarge rapidly.

Secondary or metastatic tumors to the breast from other childhood cancers tend to appear nonspecific on sonograms. Tumors secondary to leukemia usually are solid, hypoechoic, and well-defined masses (see Figure 7). Metastatic neuroblastoma in the breast might be characterized on a sonogram by multiple hypoechoic lesions.

Confirmation of a diagnosis for a metastatic breast lesion begins with fine-needle aspiration biopsy or core-needle biopsy. Metastatic lesions typically are associated with disease elsewhere in the body and a poor prognosis.

**Role of the Radiologic Technologist**

High-quality ultrasonography images can be obtained using 5 MHz to 12 MHz linear transducers. The specific transducer chosen depends on the patient's level of breast development. Fat in normal breast structure is hypoechoic, fibrous tissue is echogenic, and glandular tissue has intermediate echogeneity but appears echogenic in relation to fat.

Imaging of young breasts differs from imaging adult breasts, and radiologic technologists should become familiar with industry best practices and institutional or department protocols regarding appropriate use of technique factors for individual children's anatomy. In addition, technologists should realize that children and adolescents referred for breast examinations have highly suspicious breast masses and potentially highly anxious parents.

**Patient-Centered Care**

Patient- and family-centered care warrant special consideration from all members of the health care team when diagnosing and managing breast disease.

in children and adolescents. A child’s family typically serves as the primary source of support and plays a critical role in the child’s development and nurturing. All decisions and communication should consider the needs of the pediatric patient within the context of the family’s support and involvement in communication and decision-making. Normal security and support can be upset by a child’s potential or positive cancer diagnosis.51

Radiologic technologists often can ease patient anxiety and parent or caregiver anxiety by allowing the adult family member to be present as appropriate during diagnostic medical examinations and by ensuring the parent that all proper shielding and other radiation protection principles are being followed during examinations. Technologists also should be prepared to discuss with parents the reasons for immobilization devices or techniques and for parent shielding as appropriate.53

Patient-centered care includes understanding the unique needs of patients at various ages and from various cultures. Learning about children’s cognitive, emotional, and behavioral development complements a well-rounded education for technologists about normal physical and breast development for children and adolescents.1,51

Along with concerns about a patient’s age and involvement of the parent, radiologic technologists performing ultrasonography and other examinations on pediatric patients’ breasts must remain aware of patient modesty and potential parental and family cultural concerns about the child being examined.44 Technologists who have never performed breast imaging examinations on children or adolescents should carefully review institutional and departmental policies regarding informed consent and the presence of a parent or family member in the examination room.

Patient Safety

Radiation safety is a natural concern for parents whose children are receiving breast imaging examinations. Evidence supports concerns regarding exposure to moderate- or high-dose radiation for young patients and the risk of breast cancer development later in life. Although less evidence exists to support increased risk from the low doses associated with chest radiographs and other imaging examinations, even in girls and women who have BRCA mutations, it is best practice to provide appropriate breast shielding for all young girls having examinations in which the breasts are exposed to the x-ray beam or scatter.65 Evidence suggests that cumulative radiation from higher-dose examinations such as CT can increase risk of later cancer in children.56

Radiologic technologists serve as patient advocates and often as parent educators. They also ensure that all imaging examinations are conducted according to the ALARA, or as low as reasonably achievable, principle. As education improves through efforts such as the Image Gently program, parents and referring physicians become more aware of radiation effects. Through literature and practice guidelines, practitioners are beginning to recognize that making cautious and appropriate choices for breast imaging and for all diagnostic examinations, including trauma imaging, can reduce exposure to radiosensitive areas of children’s anatomy. This includes choosing ultrasonography rather than examinations that use ionizing radiation when clinically appropriate.47,58

Egan et al retrospectively evaluated records of 179 female pediatric patients who had received conventional radiography or CT for assessment of the thoracic spine following trauma. The authors reviewed average radiation dose to the thoracic spine from both examinations and determined excess absolute risk. Because CT of the thoracic spine resulted in a high dose of radiation compared with thoracic radiographs, the authors suggested balancing concern for missed injury with increased radiation risk and development of protocols to encourage prudent use of ionizing radiation in young female trauma patients.57

Working with a carefully constructed patient-centered care model designed for pediatric patients, radiologic technologists can create or improve the safety culture in their departments, preventing potential errors in patient identification, radiation dose, or contrast administration. Establishing pediatric-specific policies and reporting best practices also can improve overall patient safety.59

Conclusion

Although breast disease is rare in children and adolescents, it is difficult to diagnose, in part because
it occurs so infrequently. As a result, clinicians have less experience treating pediatric patients with breast masses or abnormalities, and the paucity of data and reports in the literature offers limited information. In addition, characteristics of benign and malignant masses often overlap clinically and on medical imaging. A conservative approach to imaging and management is recommended.

References


Teresa G Odle, BA, ELS, is a freelance writer and editor who has been a frequent contributor to Radiologic Technology for more than 14 years. She is the former editor of Radiologic Technology and the coauthor of several ASRT white papers and special reports. Odle also writes consumer feature and medical articles and formerly worked for a radiology practice and a large health care system in New Mexico. She lives in Ruidoso Downs, New Mexico.

Reprint requests may be mailed to the American Society of Radiologic Technologists, Communications Department, at 15000 Central Ave SE, Albuquerque, NM 87123-3909, or e-mailed to communications@asrt.org

© 2015 American Society of Radiologic Technologists...


Breast Disease in Children and Adolescents

To earn continuing education credit:
- Take this Directed Reading quiz online at www.asrt.org/drquiz.
- Or, transfer your responses to the answer sheet on Page 330M and mail to ASRT, PO Box 51870, Albuquerque, NM 87181-1870.

New and rejoining members are ineligible to take DRs from journal issues published prior to their most recent join date unless they have purchased access to the quiz from the ASRT. To purchase access to other quizzes, go to www.asrt.org/store.

*Your answer sheet for this Directed Reading must be received in the ASRT office on or before this date.

Read the preceding Directed Reading and choose the answer that is most correct based on the article.

1. Of all breast cancers, ______% occur during childhood.
   a. 0.01
   b. 0.1
   c. 1
   d. 10

2. Most solid breast masses in female patients aged younger than 19 years are:
   a. phyllodes tumors.
   b. metastases.
   c. secretory carcinomas.
   d. fibroadenomas.

3. According to the Growing Up Today Study, girls and young women had:
   a. a higher incidence of benign breast disease if their mothers had a history of breast cancer.
   b. a higher risk of breast cancer if their mothers had a history of breast cancer.
   c. only a risk of breast cancer if their mothers had breast cancer before age 50 years.
   d. no risk of benign or malignant breast disease if their mothers had a history of breast cancer.

4. Unilateral breast development at pubertal onset can continue up to ______ before the contralateral breast becomes palpable.
   a. 4 months
   b. 1 year
   c. 2 years
   d. 4 years
5. Rare cases of malignant phyllodes tumors have been associated with:
   a. Li Fraumeni syndrome.
   b. Mafucci syndrome.
   c. Cowden syndrome.
   d. the genetic marker CD117.

6. Which of the following statements is true regarding early breast development?
   a. In utero breast development begins between 1 and 2 weeks of gestation.
   b. The nipple cannot be seen at birth.
   c. The nipple is fully advanced at birth.
   d. Maternal estrogen begins influencing breast development by the third trimester of pregnancy.

7. Breast development in Tanner stage III is characterized by which of the following?
   a. a palpable subareolar bud but no elevation of the bud
   b. no separation between the areola and breast contour
   c. enlarged and mounded areola and papilla
   d. a projected papilla and receded areola

8. Normal breast development related to puberty begins between age 8 and 13 years.
   a. true
   b. false

9. Precocious puberty most likely occurs because of:
   a. high body mass index.
   b. late effects of maternal estrogen.
   c. early activation of the hypothalamic gonadotropin-releasing hormone.
   d. ethnicity.

10. Diagnosis of suspected precocious puberty can include:
    1. radiologic bone age assessment.
    2. pelvic and abdominal ultrasonography.
    3. mammography.

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

11. Which of the following is a developmental abnormality that causes formation of accessory nipples?
    a. amastia
    b. macromastia
    c. polymastia
    d. polythelia

12. Polymastia might be associated with ______ abnormalities.
    a. cardiovascular
    b. renal
    c. ovarian
    d. thyroid

13. Transient hypertrophy of the breasts is:
    1. probably caused by excessive maternal estrogen.
    2. common in male and female newborns.
    3. often accompanied by bloody nipple discharge.

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3
14. Juvenile hypertrophy usually is managed with:
   a. immediate reduction mammoplasty.
   b. antiestrogen agents.
   c. androgen therapy.
   d. watchful waiting and counseling.

15. Which of the following statements is true regarding gynecomastia?
   a. Gynecomastia is a malignant disease.
   b. An imbalance of androgen and estrogen is the likely cause of gynecomastia.
   c. Fewer than 50% of newborn boys have transient gynecomastia.
   d. Most abnormal development in boys occurs after infancy and before puberty.

16. Galactoceles are cystic masses made up of which type of substance?
   a. clear
   b. milky
   c. bloody
   d. mucous

17. On sonograms, asymptomatic retroareolar cysts appear as masses.
   1. single or multiple anechoic
   2. round or lobular
   3. hyperechoic
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

18. The most common infective agent in inflammatory breast lesions is:
   a. Bacteroides species.
   b. Streptococcus species.
   c. Staphylococcus aureus.
   d. Enterococcus species.

19. Cysts in adolescent girls commonly form:
   1. in the upper outer quadrant of the breast.
   2. in the nipple and areolar region.
   3. as solitary cysts.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

20. Benign lesions are ______ times more common in children and adolescents than malignant lesions.
   a. 10
   b. 50
   c. 100
   d. 500

21. Fibroadenomas occur:
   a. most often before a child reaches puberty.
   b. equally in boys and girls.
   c. slightly more often in whites than in African Americans.
   d. mostly in the upper outer quadrant of the breast.

22. Growth of fibroadenomas is affected by hormone fluctuations related to menstrual cycles.
   a. true
   b. false

23. Giant fibroadenomas can be identified on ultrasonography by the appearance of:
   a. multiple vascular networks.
   b. dilated ducts.
   c. fluid-filled clefts.
   d. echogenic debris.
24. Fibroadenomas should be evaluated with fine-needle aspiration if they reach a size greater than ______cm.
   a. 2  
   b. 3  
   c. 5  
   d. 7

25. Benign breast masses with small wartlike projections and a number of cysts and dilated ducts within dense areas of connective tissue are features of which of the following?
   a. juvenile papillomatosis  
   b. fibroadenomas  
   c. hemangiomas  
   d. hematomas

26. On magnetic resonance imaging, juvenile papillomatosis lesions are distinguished by:
   1. lack of enhancement.  
   2. their lobulated appearance.  
   3. small internal cysts.
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

27. Physicians now believe that granular cell tumors develop in ______ cells.
   a. lactiferous  
   b. muscle  
   c. perineural  
   d. mammary primordial

28. Which of the following often displays a leaflike pattern histologically?
   a. fibroadenomas  
   b. pseudoangiomatous stromal hyperplasia masses  
   c. phyllodes tumors  
   d. adenocarcinoma masses

29. One method for distinguishing phyllodes tumors from benign fibroadenomas on sonograms is that phyllodes tumors' internal echotextures are not uniform.
   a. true  
   b. false

30. Secretory carcinoma:
   1. seldom spreads regionally or distantly.  
   2. can recur locally.  
   3. usually are firm, painless, and progressively growing masses.
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

31. On sonograms, secretory carcinomas:
   1. appear as single microlobulated, hypoechoic masses.  
   2. resemble fibroadenomas.  
   3. appear round or oval.
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

32. The majority of angiosarcomas are of histologically ______ grade and contain a network of ______.
   a. low, stroma  
   b. low, vascular channels  
   c. high, fibrous tissue  
   d. high, connective tissue

continued on next page
Directed Reading Quiz

33. According to the article, known primary cancers in children that result in breast malignancies include lymphoma, leukemia, neuroblastoma, and which of the following?
   1. melanoma
   2. Ewing sarcoma
   3. rhabdomyosarcoma

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

34. Which of the following are characteristics of metastatic breast masses?
   1. large
   2. solitary
   3. prone to rapid enlargement

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

35. Radiologic technologists often can ease patient anxiety and parent or caregiver anxiety by:
   1. allowing parents or caregivers to be present as appropriate.
   2. discussing immobilization.
   3. discussing parent shielding.

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3