Imaging of the Adolescent Breast

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Abstract

The mainstay of breast imaging in the adolescent is ultrasonography. There is occasionally a need for additional imaging, particularly with magnetic resonance imaging (MRI). Imaging of the adolescent breast differs substantially from the adult in both the imaging modalities utilized and the relative likelihood of pathologies encountered. The majority of lesions in the adolescent are benign, but the presence of a breast lesion may cause anxiety to patients and their families due to the wide awareness of breast malignancy in the adult population. It is important to be aware of the imaging modalities available to image the adolescent breast to prevent unnecessary radiation exposure while answering the clinical question. The current recommendations for adolescent diagnostic and screening breast imaging will be reviewed. Benign breast lesions such as fibroadenomas, fibrocystic change, pseudoangiomatous stromal hyperplasia, gynecomastia, and posttraumatic or infectious lesions with their associated imaging findings and management will be outlined. Additionally, review of breast malignancies that can affect adolescents will provide the reader with features to distinguish benign from malignant processes in the adolescent based on imaging findings and clinical presentation.

Keywords

- breast
- adolescent
- imaging
- mammogram
- ultrasound
- magnetic resonance imaging

The mainstay of breast imaging in the adolescent is ultrasonography. There is occasionally a need for additional imaging, particularly with magnetic resonance imaging (MRI). Imaging of the adolescent breast differs substantially from that of the adult population. Adolescent breast imaging exams are typically triggered by a specific concern, in contrast to the adult population where the focus of breast imaging is most often on screening. The modalities also differ. Targeted ultrasound is the primary modality used for evaluation of the adolescent breast; mammography is the gold standard for screening evaluation in adults. Despite these differences, adolescent patients and their families present with concerns similar to those of adults during breast imaging evaluation due to the wide awareness of breast cancer. Knowledge of the modalities used for imaging the adolescent breast, indications for imaging, and management of pathologies that may prompt a breast imaging evaluation will be discussed in this article.

Modalities Available for Imaging of the Adolescent Breast

Mammography

Although mammography is the mainstay of breast imaging in the adult population, it is not recommended as the first modality for evaluation of an adolescent breast lesion.¹ There are several reasons why mammography is not used routinely. The adolescent breast is usually denser than the adult breast, which can limit the sensitivity of mammography. Additionally, the principle of radiation exposure in children and adolescents is to keep their radiation dose as low as reasonably achievable; therefore, exposure to radiation from mammography is avoided when possible. However, if a lesion suspicious for malignancy is detected on targeted ultrasound, a mammogram could be considered following the ultrasound to further characterize the finding and assess for sonographically occult lesions.¹

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Ultrasound

Breast ultrasound is the imaging modality of choice for the evaluation of an adolescent presenting with a breast concern and should be performed with a high-frequency (10 MHz or higher) linear array transducer.^{1,2} In contrast to mammography, there is no radiation exposure. Exams are targeted to a specific area of concern, and in conjunction with a detailed physical exam, an accurate diagnosis can be achieved for most children with a breast mass.³ Ultrasound is effective in differentiating cystic from solid masses, while maintaining a negative predictive value of 99.5% when the Stavros criteria for benign and malignant masses is utilized.⁴ If percutaneous aspiration or biopsy is necessary, ultrasound can also be utilized for image-guided intervention.

Breast Magnetic Resonance Imaging

Breast magnetic resonance imaging (MRI) is not routinely used for evaluation of an adolescent breast mass. If a patient has a greater than 20% lifetime risk of developing malignancy (strong family history, BRCA1 or 2 genetic mutation carrier, or with a personal history of mantle radiation), breast MRI may be indicated for screening, which usually does not begin before age 25 years or 8 years after chest radiation therapy, whichever is later.⁵ A breast MRI may also be useful for evaluation of a known malignancy, metastatic disease, recurrent disease, or for a better definition of lesions or anatomy prior to surgery.

Nuclear Medicine Breast Imaging

Multiple nuclear medicine techniques are being evaluated in the adult population utilizing radiotracers, which show uptake in the breast. These include positron emission mammography (PEM), molecular breast imaging (MBI), and breast specific gamma imaging (BSGI). Although these modalities offer functional rather than anatomic information regarding the breast, which eliminates the issue of dense breast tissue in the adolescent, research has primarily focused on detection and characterization of breast malignancy, which has a very low prevalence in the adolescent population. These exams also require an injection of a radioactive tracer, which is avoided in children and adolescents when possible to keep radiation exposure as low as possible.

Indications for Breast Imaging

Routine screening of the adolescent breast is not recommended for several reasons. The prevalence of malignancy in the adolescent population is 0 cases per 100,000 women per year, making screening much less effective than in the adult population, and not justified for the general adolescent population.^{6,7} Additionally, given the increased density of the adolescent breast, mammography is less sensitive in detecting lesions in young patients. However, for young women who have a history of chest irradiation, annual clinical breast examinations beginning at the onset of puberty are recommended with annual mammography and breast MRI beginning at age 25 or 8 years following the completion of therapy, whichever is later.⁵ Most current recommendations for those

with a genetic mutation or strong family history are to commence screening with mammogram and adjunctive breast MRI at age 30 or 5 years prior to the age of the youngest family member with the disease.⁸

There are several clinical presentations for which breast imaging is indicated in an adolescent. Palpation of a worrisome mass (> 5 cm in size, growing, associated with skin tethering, history of known malignancy or mantle radiation, or constitutional symptoms), unilateral spontaneous bloody or clear nipple discharge, breast infection with possible abscess, or focal breast pain are indications to initiate breast imaging with ultrasound.

Imaging of Breast Pathology

Developing Breast Bud

Thelarche, or the onset of pubertal development, usually begins between the ages of 8 to 13.⁹ The development of the breasts can be asymmetric, and patients may present for evaluation of a palpable mass that in fact is a normal breast bud. At different stages of development, the appearance of the breast bud varies on ultrasound. In the prepubertal stage (Tanner stage I), there is heterogeneous tissue in the retro-areolar breast.¹⁰ As the breast bud develops in Tanner stage 2, a hyperechoic subareolar nodule with a central hypoechoic linear or stellate area develops.¹¹ As the patient moves into Tanner stages 3 and 4, the hypoechoic region increases with finger-like or nodular extensions into the surrounding tissue (**Fig. 1**).¹¹ Tanner stage 5 represents the mature breast with involution of the subareolar hypoechoic focus and echogenic fibroglandular tissue remaining.¹⁰ Tanner staging of puberty is based on physical findings. Breast imaging is not indicated to establish breast maturity, though it might be helpful in the obese patient where Tanner staging can be more difficult.

Thelarche before the age of 7½ years is considered premature, and patients with isolated premature thelarche usually do not progress beyond Tanner stage III.¹² If physical exam or sonographic evaluation demonstrates findings of Tanner stage IV or V or clinical evidence of sexual maturation, precocious puberty, a pseudo or incomplete precocious puberty, or exogenous estrogen exposure should be considered.¹² Sonographic evaluation of the pelvis to assess for maturation of the uterus and ovaries and detect presence of ovarian cysts or neoplasm should also be performed if premature estrogenization is suspected.

Gynecomastia

Gynecomastia is the presence of excessive, benign subareolar tissue in the male breast. Clinically, patients present with a tender, mobile, subareolar mass. It is a common finding in the adolescent boy, present in 75% of boys with a peak incidence at age 13 to 14 years.¹⁰ It can be asymmetric, unilateral, or bilateral, and usually resolves within 2 years.¹⁰ It is idiopathic in approximately 25% of adolescent boys, but etiologies that increase the ratio of estrogen to testosterone can also cause gynecomastia to develop.¹³ Medications, such as corticosteroids, cimetidine, digitalis, and tricyclic antidepressants, and drug use such as marijuana and anabolic steroids can cause

Fig. 1 An 11-year-old girl with a palpable, painful subareolar mass. (A) Sonogram shows a hypoechoic region in the subareolar right breast with finger-like extensions into the subcutaneous tissues, consistent with a developing breast bud. This corresponded to the palpable concern. (B) Sonographic comparison to the asymptomatic breast shows a similar appearance.

development of the male breast.^{10,14} Uncommon causes are estrogen or gonadotropin-producing tumors, Klinefelter syndrome, liver disease, choriocarcinoma, prolactinomas, and adrenal cortical tumors.^{9,10,14}

Though the diagnosis is usually made clinically, ultrasound shows a variable appearance to gynecomastia. It can be nodular with an oval hypoechoic region in the subareolar breast, poorly defined as a vague hypoechoic structure in the retroareolar region, or flame-shaped with finger-like extensions into the surrounding tissue.¹⁴ Mammography, though not indicated, can also have a variable appearance, with nodular, dendritic, and diffuse forms described.¹⁵ Nodular gynecomastia usually appears as a flame-shaped density that blends into the surrounding fat, but can appear more rounded. The dendritic form shows extensions of subareolar tissue into the deeper adipose tissue, and is usually indicative of long-standing gynecomastia. The diffuse form has an appearance similar to a female breast with heterogeneously dense parenchyma.¹⁵ The clinical significance of the variable findings on imaging is not known.

Fibroadenoma

Fibroadenomas represent over half of breast masses in the adolescent population in surgical series, presenting as palpa-

ble, circumscribed, rubbery, mobile masses.^{10,16,17} The cause of fibroadenomas is unknown, but hormonal influences are believed to play a factor in their development as a significant number of fibroadenomas change with hormonal stimulation.¹⁸ The average size is 2 to 3 cm. The term *giant fibroadenoma* refers to lesions > 5 cm in diameter. The average patient age at diagnosis is 15 to 17 years.¹⁰ Giant fibroadenomas are uncommon, representing approximately 7 to 8% of fibroadenomas.^{16,19} Fibroadenomas typically grow slowly, and with time may decrease in size or completely regress.^{18,20}

On ultrasound, fibroadenomas are typically oval or lobulated in shape, isoechoic or hypoechoic in comparison to the surrounding fat, with circumscribed margins, and are parallel to the chest wall. Anechoic areas within the fibroadenomas have been described in the adolescent population, thought to be secondary to a large amount of epithelial tissue.²¹ With Doppler evaluation, fibroadenomas may show internal vascularity or appear avascular.

Management of adolescent fibroadenomas is usually conservative, with clinical and sonographic follow-up appropriate in most cases.^{16,22} If a lesion is rapidly growing, > 5 cm, or causing deformity of the breast, surgical consultation is warranted.²³ Core needle biopsy prior to surgical excision can be desirable to assist with preoperative planning.

Pseudoangiomatous Stromal Hyperplasia

Pseudoangiomatous stromal hyperplasia (PASH) is a benign myofibroblastic proliferation in the breast, which is hormonally responsive. Most commonly, it presents as a microscopic form incidentally noted in pathologic specimens.²⁴ However, PASH can also present as a breast mass in children and adolescents.^{25,26} Its most common appearance on ultrasound is of an oval circumscribed hypoechoic mass, occasionally with an internal cystic component (► **Fig. 2**).²⁷ In adolescents, PASH can show rapid growth.²⁸ If diagnosed on core needle biopsy, this benign process can be managed conservatively with observation. If it increases in size or there are suspicious features on imaging, surgical excision is warranted.²⁹ PASH can regress spontaneously, but recurrence following surgical excision has been reported in 9 to 26% of cases.^{29,30} Timing of surgery when there is diffuse involvement of the breast is an important consideration to achieve optimal outcome.

Breast Cysts

Fibrocystic change represents a range of findings from benign solitary simple cysts to proliferative fibrocystic changes. Breast cysts or fibrocystic changes are present in approximately 8.5% of this population.³¹ Breast cysts can be solitary or multiple, simple or complicated. The debris within complicated cysts can result from blood, pus, or hemorrhage and may mimic the appearance of a solid mass on ultrasound.³² The features of a complicated cyst are otherwise the same as simple cysts, with circumscribed margins, posterior acoustic enhancement, and a thin imperceptible wall. The differential diagnosis of a complicated cyst also includes a hematoma, galactocele, or abscess. Clinical history will usually assist in distinguishing these entities.

Fig. 2 A 16-year-old girl with a palpable mass. Sonogram shows an oval, circumscribed hypoechoic mass, which is parallel to the chest wall. The appearance is similar to that seen with a fibroadenoma. Ultrasound-guided biopsy demonstrated pseudoangiomatous stromal hyperplasia.

In adolescent girls, retroareolar cysts can develop from obstruction of the glands of Montgomery at the periphery of the areola. Patients present with a palpable nodule in the subareolar breast that can be associated with pain and erythema secondary to inflammation. Ultrasound demonstrates an oval, round, or elongated cyst in the periareolar breast, which is bilateral in 49% of patients.³³ If painful or inflamed, increased Doppler flow at the periphery of the cyst is seen.³³ These lesions are managed conservatively with antibiotics and antiinflammatory medication if symptomatic, and tend to resolve spontaneously.³³

Posttraumatic Lesions

Posttraumatic lesions in the adolescent breast include hematomas and fat necrosis, which frequently are secondary to sports-related injuries or iatrogenic trauma.^{9,10} On ultrasound, hematomas are complex cystic masses that vary in appearance with the age of the hematoma, initially hyperechoic and becoming increasingly anechoic with time. Fat necrosis also has a widely variable appearance on imaging, presenting on mammography as a mass, focal asymmetry, lipid cyst, or microcalcifications, which can have a benign or suspicious morphology.³⁴ On ultrasound, a hyperechoic or mixed echogenic mass with variable cystic spaces, a cystic lesion, or hypoechoic mass with or without posterior acoustic shadowing can be seen.³⁴ Clinical history of a traumatic event to the breast can lead to the appropriate diagnosis; short-term follow-up of these lesions allows evaluation of their expected benign evolution.

Abscess and Mastitis

Patients who develop an infection of the breast can present with fever and an erythematous, painful breast with or without systemic symptoms, including fever. Mastitis is most often seen in lactating women, but nipple injury or

piercing, areolar hair plucking, ductal obstruction, breast trauma or cellulitis can be other etiologies.^{9,35} In adolescents, an etiology is often not identified. With ultrasound, the breast is edematous and hyperechoic, with loss of differentiation of the normal breast architecture; the tissue can be difficult to penetrate with a high-frequency transducer.³⁶ If an abscess develops, a complex cystic mass with a thick wall and peripheral Doppler flow may be seen (**Fig. 3**). Ultrasound-

Fig. 3 A 15-year-old girl with 2-week history of painful breast mass and fever. (A) Sonogram shows a round cystic lesion with low-level internal echoes and increased through transmission. (B) There is increased vascularity peripherally, but no internal flow with Doppler interrogation. (C) The lesion was completely aspirated under ultrasound guidance, yielding 2 mL of purulent fluid, compatible with an abscess. At the time of follow-up 2 weeks later, the patient's symptoms resolved and no residual abscess was seen sonographically.

guided aspiration is both diagnostic and therapeutic. If lesions reaccumulate, repeated aspirations can be performed, or ultrasound-guided drain placement can be considered.

Galactocele

A galactocele is a benign epithelial-lined cyst filled with milky fluid, usually present in a lactating woman.¹⁰ Galactoceles have also been reported in adolescent boys in the absence of endocrine dysfunction.^{37,38} The imaging appearance is dependent on the relative proportion of fat to water within the fluid. On a true lateral mammogram, a fat-fluid level can be seen. Sonographically, lesions are seen as complex cystic masses with a hyperechoic fatty component. On MRI, mild enhancement of the peripheral margins and internal septations has been described.³⁸ Ultrasound-guided aspiration of milky fluid is both diagnostic and therapeutic.

Intraductal Papilloma

Benign intraductal papilloma is a rare lesion in adolescents, but it has been reported in adolescent girls and boys.^{9,37} Patients can present with clear or bloody unilateral spontaneous nipple discharge. Histologically, a papilloma represents an epithelial proliferation within the duct. Lesions are usually located in the subareolar region and most often solitary; in approximately 25% of cases, they can be bilateral.⁹ On ultrasound, a hypoechoic or isoechoic mass sometimes within a dilated duct or surrounded by anechoic fluid is seen.¹⁰ On MRI, there is variable enhancement of a mass that is often intraductal or intracystic, or associated with a dilated duct.³⁹

Juvenile Papillomatosis

Juvenile papillomatosis, or "swiss cheese disease," is a rare, benign, proliferative process that has been described in both adolescent girls and boys.^{40–42} Patients typically present with a firm, mobile, circumscribed mass, unassociated with nipple discharge.⁴² On ultrasound, an ill-defined solid or complex cystic mass has been described. MRI shows numerous small cysts within the lesion on T2-weighted imaging.⁴³ Patients who have a family history of breast cancer, atypical or bilateral lesions, multifocal lesions, or recurrence of juvenile papillomatosis after surgical excision may be at increased risk of developing malignancy.⁴²

Phyllodes

Phyllodes tumors are rare, but are the most common malignant breast mass in adolescents.¹¹ They are classified histologically as benign, borderline, or malignant; 5 to 24% fall into the malignant categorization in the pediatric population.¹⁰ On histopathology, the lesions are characterized by stromal cellularity and increased mitotic activity, with epithelial-lined spaces or clefts.¹⁰ Regardless of the histology, local recurrence and metastases can occur, but the most important prognostic feature is the mitotic activity.^{44–46}

On mammography (rarely indicated in adolescents) and ultrasound, the appearance of a phyllodes tumor can mimic that of a fibroadenoma, presenting most frequently as an oval or macrolobulated, circumscribed, hypoechoic mass

Fig. 4 An 18-year-old girl with a growing breast mass. Sonogram shows a 5.4-cm oval circumscribed hypoechoic mass, which had increased in size from 3.8 cm 6 months previously. Surgical excision demonstrated a benign phyllodes tumor.

(→**Fig. 4**). The internal echotexture can be heterogeneous, sometimes with anechoic cysts or clefts.^{21,46} However, this appearance has also been described in benign fibroadenomas.¹⁰ On MRI, a well-circumscribed round or lobulated mass has also been described, similar to a fibroadenoma. Non-enhancing internal septations are more commonly seen in phyllodes tumors than fibroadenomas, and both lesions can show suspicious enhancement characteristics.⁴⁷ There is variable increased signal on T2-weighted images and lesions are isointense to hypointense relative to breast tissue on T1-weighted imaging.⁴⁷ Due to the similarity in imaging features, reliably distinguishing phyllodes tumors from a fibroadenoma is not possible on imaging alone. However, the clinical course may provide a clue to the diagnosis. Phyllodes tumors usually present as a palpable, enlarging mass that can grow rapidly; in children, most phyllodes tumors are > 6 cm at the time of presentation.¹¹

Management of a phyllodes tumor is surgical, with wide surgical margins.⁴⁸ If a phyllodes tumor is borderline, malignant, or recurs following surgical excision, mastectomy with immediate breast reconstruction may also be an option.^{48,49} Metastases spread hematogenously, most commonly to the lungs, but are rare in adolescents.^{46,50,51}

Other Breast Malignancies

Primary breast malignancies other than phyllodes tumors are extremely rare in adolescents. Clinically, patients present similar to adults with a palpable, firm mass, which is distinct from the nipple and breast bud.^{52,53} Secretory carcinoma is the most common subtype of primary breast cancer to occur in adolescents and has a good prognosis.^{10,53} There are case reports of other less common types, including infiltrating ductal and lobular, anaplastic, medullary, and inflammatory carcinomas.^{10,53} With sonography, primary malignancies are similar to suspicious masses in adults, manifesting as irregular, hypoechoic mass with

suspicious margin characteristics and variable posterior acoustic features.^{4,54}

Angiosarcoma can also occur as a primary breast malignancy in adolescents. Lesions in adolescents are usually low grade with a better prognosis than lesions in the adult population.^{10,55,56} Angiosarcoma can present as a painless mass that can grow rapidly with a blueish or reddish discoloration of the skin.⁵⁵ Most imaging reports of angiosarcoma have been described in the adult population. Mammographically, 33% of angiosarcomas are occult.⁵⁶ When a lesion is seen, it can be a noncalcified mass or focal asymmetry.⁵⁵ There is a variable appearance on ultrasound; masses can be circumscribed or ill-defined, or mixed echogenic or hyperechoic regions can be seen without a discrete mass.^{55,57} With MRI, a low T1-, high T2-signal intensity mass with irregular focal areas of high T1 signal can be seen.⁵⁸ Enhancement correlates with the grade, with low-grade lesions demonstrating progressive enhancement, and high-grade lesions demonstrating rapid initial enhancement and wash-out kinetics.⁵⁵ MRI is helpful in assessing the extent of disease, preoperative planning, and assessing margins following incisional biopsy.

More commonly seen than primary breast malignancies are metastatic lesions, including rhabdomyosarcoma, leukemia, lymphoma, and neuroblastoma. Rhabdomyosarcoma metastasizes to the breast in 6% of adolescents and children affected, and can, though rarely, present as a primary malignancy within the breast.⁵⁹ On ultrasound, lesions appear as hypoechoic round or lobulated masses with posterior acoustic shadowing or absent posterior acoustic features. Findings on MRI are nonspecific, but lesions can show peripheral rim enhancement.^{59–61}

The imaging of metastatic lesions to the breast shows a variable appearance. Metastases to the breast can be multiple, bilateral masses or unilateral and solitary.⁶² Leukemia and lymphoma can be seen as hypoechoic masses with circumscribed or suspicious margins and variable posterior acoustic features; adenopathy may provide a clue to the underlying pathology.¹⁰ Multiple hypoechoic masses can also be seen with metastatic neuroblastoma.⁶³ A patient with a known primary malignancy who presents with a new breast mass detected on physical exam or surveillance imaging should undergo prompt diagnostic breast imaging evaluation with core needle biopsy.^{62,64}

Conclusion

There is a wide range of pathology that can affect the adolescent breast. In most cases, an adolescent patient presenting with a breast concern will have a benign lesion, but it is important to be aware of rare malignant causes and the indications for surgical intervention. Appropriate use of imaging is important in this population to avoid unnecessary radiation exposure, with ultrasound the mainstay of targeted imaging evaluation. Understanding the range of pathology, appropriate tools for imaging, and associated imaging features will facilitate appropriate treatment of these young patients.

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