Imaging Approaches to Diagnosis and Management of Common Ductal Abnormalities

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Learning objectives

The ductal system of the female breast is a specialized region of the mammary gland. It is a major anatomic landmark of the breast, serves to drain and express breast milk during lactation, and contains specialized cells for this function. It may be affected by a broad spectrum of diseases that have similar imaging appearances. Optimal clinical and diagnostic techniques are needed for best evaluation of this region because of the complicated anatomy. A comprehensive understanding of the ductal anatomy and benign and malignant processes and the imaging features of each lesion is essential for accurate differentiation and diagnosis.

In this presentation, we propose to attend these objectives:

- Describe the imaging appearance of normal ductal anatomy.
- Discuss the methods for imaging evaluation of ductal abnormalities.
- Show the radiologic findings of benign and malignant disease associated with the ductal system.
Background

The ductal system may be affected by a broad array of disease processes. It can be related to benign conditions, such as intraductal papilloma, duct ectasia, plasma cell mastitis or galactorrhea; or to malignant conditions such as ductal, carcinoma and Paget disease.

The most common finding with all modalities is ductal dilatation with a focal or diffuse abnormality.

A thorough understanding of ductal anatomy, benign and pathologic processes, and the imaging features specific to each is the necessary basis for a comprehensive and appropriate imaging assessment, diagnosis, and, if necessary, intervention.

1/ Ductal anatomy:

A recent comprehensive evaluation of nipple and ductal anatomy confirms that the majority of nipples (>90%) contain five to nine ductal orifices organized into two groups: peripheral and central. The central ducts tend to extend to the chest wall, while the peripheral ducts are arranged in a radial fashion. Each duct divides into segmental and subsegmental ducts, which ultimately culminate in terminal ducts and blunt-ending acini of the lobules (fig 1).

An uninterrupted basement membrane surrounds the ductal system. The basement membrane demarcates the boundary that determines whether a tumor is considered in situ or invasive.

The terminal ductal-lobular unit (TDLU) is considered the functional unit of the breast and contains the acini responsible for milk production. The majority of diseases arise in the terminal ductal-lobular unit.

Stroma is the connective tissue that surrounds the TDLUs and contains capillaries and other specialized cells.

The infrastructure of the breast is provided by Cooper ligaments, which are dense strands of fascia found throughout the entire breast and terminate at the skin.

There are no true anatomic lines denoting each segment and segments may cross into multiple quadrants, making resection of a specific segment at surgery challenging.

A recent evaluation disputes the presence of any anastomoses between ductal systems, showing instead that subsegmental branches from adjacent ductal systems interdigitate with one another without communicating, subsequently terminating in their own specific TDLU.
2/The methods for imaging:

Imaging evaluation of the ductal system usually entails a combination of mammography, galactography, ultrasonography (US), and in some cases magnetic resonance (MR) imaging.

2.1. Galactography or ductography:

This technique developed many decades ago was abandoned, but recently has been put back into use owing to improved mammographic technology.

It was previously suggested that patients with abnormal nipple discharge should undergo routine ductography and dye localization before surgery. However, ductography can only be performed if the nipple discharge is reproducible on physical examination and if the duct can be cannulated.

Galactography is accurate in identifying the location of the ductal abnormality and it allows a focused surgical approach to the pathologic lesion. Nevertheless, ductography cannot be effectively used for the differential diagnosis of a benign versus a malignant lesion, and it is not useful as a predictor of underlying pathology.

2.2. Ultrasonography (US):

US is quickly becoming the new standard of reference for evaluation of suspected ductal disease, because of its increased resolution, availability, and ease of use.

It allows visualization of ductal pathology as small as 0.5 mm in diameter. It can be used for ultrasound-guided percutaneous biopsy of lesions. It also can guide fine needle aspiration (FNA) and will help in obtaining cytology specimens from the abnormal area.

2.3. Mammography:

Mammography is recommended to any patient presenting with abnormal nipple discharge, although it has poor positive predictive value (16.7%). This percentage reveals that it is not reliable in the diagnosis of the underlying cause of nipple discharge. Only half of the patients presenting with nipple discharge who were found to have cancer had an abnormal mammography.

Mammography may reveal microcalcifications that must be evaluated.
2.4. Magnetic resonance imaging:

If galactography is noncontributory in the work-up of a patient with spontaneous nipple discharge and US did not found focal abnormality, breast MR imaging with contrast material can often add additional diagnostic information and aid in case management.

It is important to review subtraction images for disease; otherwise, subtle areas of ductal wall and associated enhancement may be overlooked.

It seems that magnetic resonance imaging (MRI) has a moderate sensitivity (>75%), a low to-moderate specificity (<65%) and a low positive predictive value (<60%) in the evaluation of nipple discharge.

3. Ductal diseases:

3.1. Benign diseases:

Benign diseases involving the ducts are relatively common in clinical practice. They range from inflammatory processes to infectious entities and intraductal papilloma.

- **Duct Ectasia**: it is an inflammatory process, usually affecting the ducts below the nipple. It is defined as non specific dilatation of one or more ducts. The duct is typically larger than 2 mm in diameter or the ampullary portion is greater than 3 mm in diameter. Duct ectasia may be visible at mammography, depending on the overall density of the breast parenchyma as well as the extent of the dilatation, as radiodense serpentine tubular structures converging on the nipple-areolar complex. Ultrasonography demonstrates anechoic smooth-walled branching structures that taper peripherally (fig 2). Duct ectasia usually accompanies benign breast conditions (fig 4), but may also be associated with breast cancer. Sonographic features that suggest a malignant process include a peripherally dilated duct (one well away from the retroareolar region), irregularity of the duct margin, focal wall thickening, and adjacent hypoechoic tissue.

- **Intraductal papilloma**: consist of epithelial proliferation on a fibrovascular stalk. A total of 60-80% of intraductal papillomas are accompanied by spontaneous or induced bloody, serous, aqueous or serobloody discharge, which is one of its main clinical findings. A 5% increased risk of developing invasive carcinoma has been reported. Characteristics that suggest an increased upgrade potential include lesion size greater than 1 cm, lesion location more than 3 cm from the nipple, and patient age greater than 50 years. Papillomas may be diagnosed by ductography, in which there is one or multiple contrast filling defects of smooth contour in the duct (fig 5) or interruption of contrast flow in the duct where the papilloma exists. At US, it typically appears as ovoid solid masse with associated ductal dilatation (Fig 5); it may appears hypervascular at color Doppler assessment. MR imaging
is practised when patients present with persistent serous or sanguineous nipple discharge but have normal results at galactography and US. In these cases, papillomas can appear as a well-circumscribed oval or round mass (fig 6), an irregular mass, or a solid and cystic lesion. Kinetic evaluation can reveal progressive, plateau, or washout-type enhancement. The presence of multiple papillomas is called papillomatosis, a common finding in menopausal women.

- **Periductal Mastitis**: typically occurs in premenopausal women when the ducts beneath the nipple become inflamed and infected. It is not uncommon to see enhancement of the duct wall in cases of chronic inflammation at MR imaging.

- **Plasma cell mastitis**: is a rare type of chronic mastitis characterized by the presence of multiple plasma cells in microscopical evaluation. Typical findings include thickened ducts and fibrosis that may be multicentric.

- **Other causes**: Apocrine Metaplasia, Blocked Ducts and Inflammatory Infiltrates (fig 3).

### 3.2. **Malignant diseases**

The most common malignant disease affecting the ductal system of the breast is ductal carcinoma in situ (DCIS).

- **Ductal Carcinoma in Situ**: (fig 7,8) By definition, the cellular proliferation is contained within the duct by the basement membrane. Typically, DCIS manifests as calcifications at mammography, although in up to 14% of cases it may manifest as a solid mass with or without associated calcifications. At US, DCIS can appear as an intraductal mass or a solid intraparenchymal mass with adjacent ductal dilatation or extension. The most commonly reported MR imaging manifestation of DCIS is clumped nonmasslike enhancement in a ductal, linear, segmental, or regional distribution.

- **Invasive Ductal Carcinoma**: (fig 9) Invasive ductal carcinoma arises from the ductal epithelium in the TDLU. At mammography, it most commonly appears as spiculated or irregular mass with or without associated calcifications or as developing asymmetries. At US, the former type of lesion can manifest as a dominant cystic area with surrounding rounded or tubular hypoechoic areas that represent ductal extension. Percutaneous biopsy of the area is warranted for definitive diagnosis. MR imaging is used when results of mammography and US are unrevealing.

- **Paget disease**: accounts for less than 5% of all breast cancers and is thought to most likely arise from preexisting DCIS or invasive ductal cancer. It relates to the nipple and ductal system. Most patients with Paget disease undergo mastectomy.
Fig. 1: Multiple ductal systems drain into a ductal sinus within a segment and subsequently empty into the nipple. Each duct divides into segmental and subsegmental ducts, which ultimately culminate in terminal ducts and blunt-ending acini of the lobules. TDLU = terminal ductal-lobular unit.

Fig. 2: Dilated ducts secondary to benign duct ectasia. US images of the left breast show tubular anechoic areas and in the retroareolar region.

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**Fig. 3:** Duct ectasia with inflammatory infiltrates. Mammography shows well-circumscribed encapsulated-appearing masses. US images of the area show focal ductal dilatation soft-tissue nodules within the duct.

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**Fig. 4:** Focal duct ectasia filled with thick secretions.

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**Fig. 5:** Papilloma in a 39-year-old woman with spontaneous nipple discharge. Galactogram shows a focal filling defect within a dilated ductal system. US image of the same area shows a dilated duct containing an isoechoic intraductal mass.

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Fig. 6: Papilloma in a 43-year-old woman with spontaneous discharge from nipple and normal results at mammography and retroareolar US. Sagittal T2-weighted and axial contrast-enhanced fat-saturated T1-weighted images show an enhancing ovoid lesion with enhancement along the ducts.

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**Fig. 7:** DCIS. Contrast-enhanced T1-weighted images show focal linear ductal enhancement in the superolateral breast as well as an associated enhancing nodule.

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**Fig. 8:** Multifocal high grade DCIS. Sagittal and axial early postcontrast images show multifocal areas of clumped enhancement extending from the nipple to posterior depth.

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Fig. 9: Invasive ductal carcinoma in a 80-year-old woman with a palpable lump in the right breast. Mammograms show irregular masse in the outer quadrant of the right breast associated with an increase of the overall density of the breast. US image shows a large irregular mass with heterogeneous echotexture. Biopsy demonstrated grade III invasive ductal carcinoma.

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Imaging evaluation of the ductal system usually entails a combination of mammography and ultrasonography, and in some cases galactography or magnetic resonance imaging.
Conclusion

Ductal disease is an important and poorly understood issue in breast imaging that results in delays in diagnosis and patient care. Optimal clinical and diagnostic techniques are needed for best evaluation of this region because of the complicated anatomy. Most commonly performed with US guidance, percutaneous biopsy methods are helpful in diagnosis and management of ductal findings.
References


