



Breast Cancer Subtypes: Clinicopathologic Features and Treatment Considerations

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Abstract

Purpose of review The purpose of this review is to provide an overview of ten unique breast cancer subtypes and their clinicopathologic features and treatment implications.

Recent findings Recent findings show that while many subtypes (mucinous, papillary, tubular, apocrine) have favorable biology, with better overall survival than invasive ductal carcinoma, some (metaplastic, adenoid cystic) are more aggressive portending worse prognosis for patients.

Summary The differences in histology represented in these breast cancer subtypes often impacts biology, behavior, and prognosis. Due to their rarity, additional research is needed to implement clear treatment protocols for each subtype.

Keywords Breast cancer subtypes · Apocrine carcinoma · Metaplastic · Papillary · Mucinous

Introduction

Primary breast carcinomas are largely of ductal or lobular histology; however, there are a myriad of other subtypes less commonly seen. While most breast cancers do fit within these two primary groupings, patients may present with unique subtypes on core biopsy or final pathology that warrant individualized consideration. It is imperative for the multidisciplinary oncology team to be knowledgeable of histologies beyond the classic ductal and lobular histologies as they may impact individualized treatment plans. In this

comprehensive review, we describe ten unique breast cancer subtypes, their epidemiology, clinicopathological characteristics, available outcomes data, and treatment implications.

Apocrine Breast Carcinoma

Apocrine breast carcinoma (APC) was first described as a unique pathological entity in the 1960s [1, 2]. The World Health Organization (WHO) currently requires $\geq 90\%$ of tumor cells have apocrine morphology on microscopic examination to fit this diagnosis [3]. Histologically, APC is characterized by large cells with round nuclei, prominent nucleoli and an abundance of granular eosinophilic cytoplasm, reminiscent of apocrine sweat glands [3, 4]. In addition to characteristic morphology, APC has a distinct biomarker profile, being estrogen receptor (ER) and progesterone receptor (PR) negative and androgen receptor (AR) positive and displaying expression of either human epidermal growth factor-2 (HER2) or epidermal growth factor receptor (EGFR) [5, 6]. (Fig. 1A). APCs have also been noted to demonstrate mRNA and protein expression for the marker gross cystic disease fluid protein 15 (GCDFP-15) by immunohistochemistry (IHC) and in situ hybridization [7]. GCDFP-15 is highly specific for mammary, and apocrine differentiation as it is regulated by the AR.

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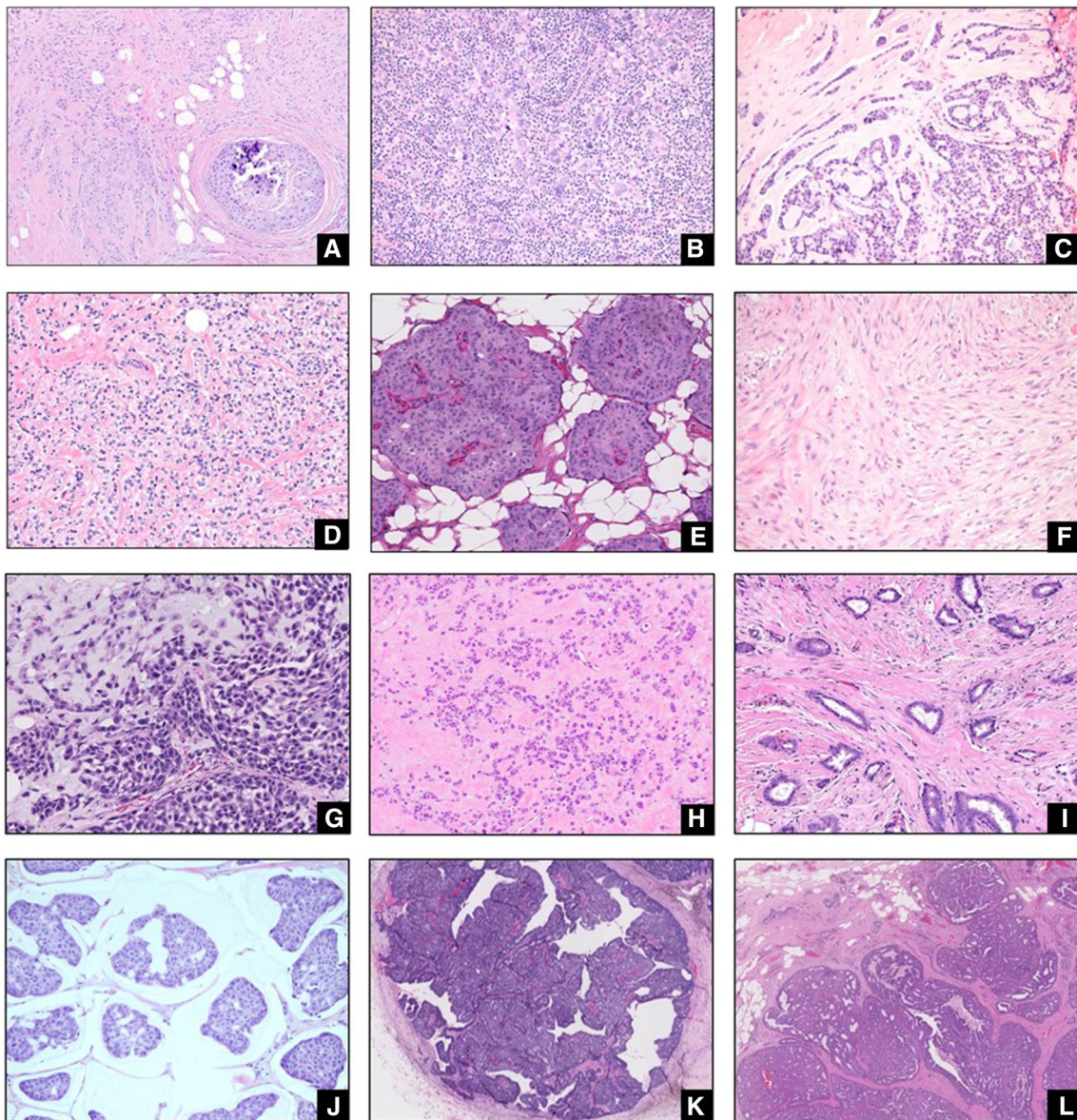


Fig. 1 A: Apocrine carcinoma (H&E, 200x); B: Invasive ductal carcinoma with medullary pattern (H&E, 200x); C: Adenoid cystic carcinoma (H&E, 200x); D: Invasive lobular carcinoma with signet ring features (H&E, 200x); E: Tall cell carcinoma with reversed polarity (H&E, 200x); F: Spindle cell metaplastic carcinoma (H&E, 200x);

G: Metaplastic carcinoma with heterologous (chondromyxoid) mesenchymal differentiation (H&E, 200x); H: Neuroendocrine carcinoma (H&E, 200x); I: Tubular carcinoma (H&E, 200x); J: Mucinous carcinoma (H&E, 200x); K: Encapsulated papillary carcinoma (H&E, 20x); L: Solid papillary carcinoma (H&E, 20x)

The annual incidence of APC is estimated to be 3–4 per 1 million women based on a 2021 analysis of the Surveillance, Epidemiology, and End Results (SEER) database from 2004–2017 and is currently the largest analysis of patients with APC ($N=2,234$) [8]. These tumors are seen more frequently in younger women, are more commonly found in Asian women, and approximately 50% are classified as triple-negative (TN) receptor subtype. Treatment of APC is like other types of breast cancer, with multimodal management of surgery, systemic therapy, and

radiation. In a cohort of 1486 cases of APC evaluated by Mills et al. using the National Cancer Database (NCDB) from 2004–2012, 57.5% received chemotherapy. In another NCDB analysis by Arciero et al., comparing triple negative APC to ductal TNBC, the rates of surgery and radiation were similar [9].

One may assume that with a less favorable receptor status, APC tumors would have poor prognosis. However, as shown in the SEER analysis, the 7-year disease specific survival of 85% appears to be similar to patients with non-APC

tumors. Additionally, when compared to other triple-negative breast cancers, TN-APC have better survival (86% vs 74%, $p < 0.001$) [8].

In the NCDB cohort, multivariate analysis of prognostic factors related to overall survival, use of chemotherapy was not significant ($p = 0.25$) [10]. Similarly, a retrospective Italian study of 36 women with primary non-metastatic TN-APC who did not receive chemotherapy observed no difference in invasive-disease-free survival when compared to 24 patients with ductal TNBC and 12 patients with TN-APC who received chemotherapy [11].

Better outcomes in this subgroup of patients have resulted in question of chemotherapy benefit and de-escalation of therapy. A nomogram has been developed to predict overall survival for patients with TN-APC based on SEER data in hopes of identifying patients at lower risk [12]. Ongoing and future efforts are underway to identify specific therapeutic targets for APC and promising work has been seen in understanding the key role the androgen-receptor (AR) and p62 play in APC [13, 14].

Breast Carcinoma with Medullary Features

Medullary breast carcinoma was first described in the 1970's and is characterized by the following 5 pathologic features: an expanding border microscopic circumscription, syncytial growth pattern, lack of ductal or tubular differentiation, high nuclear grade, and prominent associated lymphoplasmacytic infiltrate [15–17]. (Figure 1B). In 2012, the WHO expanded the classification of medullary carcinoma to describe features of breast carcinomas rather than classifying it as a single type of breast cancer. Currently, the WHO classifies tumors with this morphology as having “medullary pattern.” Biomarker expression varies, with the tumors most often TN but have been shown to demonstrate expression of ER and/or PR (< 10 to 32% of cases) and HER2 (11.0 to 20.5%) [18–21].

Medullary carcinoma comprises less than 5% of all mammary cancers. Affected patients tend to be younger, present with higher T stage, and there is a possible association with BRCA1/2 carriers. In a cohort study of 46 patients with medullary breast carcinoma by Vu-Nishino et al., 26% of patients were age 35 years or younger compared to only 6% in the control group.

Additionally, of the patients that underwent genetic testing, half had deleterious mutations in BRCA1/2 [22]. Although these tumors are frequently TN, some retrospective studies show a more favorable prognosis compared to other TNBC of ductal histology and when compared to other stage-matched high grade breast cancers [23, 24].

Lastly, whether tumors have a typical or atypical appearance does not appear to influence patient prognosis based

on a NCDB cohort analysis [25, 26••]. These findings were confirmed by a retrospective analysis from the SEER database in 2016 revealed that patients with medullary breast carcinoma were more likely to have TN disease (56.4%) but propensity score matching demonstrated no difference in overall survival (OS) or breast-cancer-specific survival when compared to other patients with IDC, or to other TNBC [27]. While the majority of these patients received systemic chemotherapy (74.5%), a separate analysis showed better OS in the 174 patients with medullary breast cancer who did not receive chemotherapy when compared to 507 who did, questioning the benefit in all patients [28].

Adenoid Cystic Breast Carcinoma

Adenoid cystic breast carcinoma (ACC) is a salivary gland-type tumor of the breast and has the most favorable long-term outcomes of any TNBC. On histopathology, it is typically a dual cell population that grows in sheets with associated fused glands comprised of myoepithelial and luminal epithelial cells arranged in tubular, cribriform, and solid nested patterns with associated basophilic matrix material [29, 30]. Figure 1C. ACC are further subtyped as classic adenoid cystic, solid-basaloid, and adenoid cystic carcinoma with high grade transformation [31]. Most ACC display *MYB-NFIB* gene fusion [32].

ACC is one of the rarest of the rare breast cancer subtypes (< 0.1% of all breast malignancies) with only case reports and small case series reported in the literature. This paucity of data results in lack of consensus regarding optimal therapy for these patients. Surgery is a mainstay of treatment, but the use of adjuvant chemotherapy remains controversial. In a population-based study by Li et al., utilizing the SEER database, only 12.4% of patients received adjuvant chemotherapy. Patients with lymph node metastasis, stage IIB and III, histological grade ≥ 2 , and no radiation had worse breast cancer-specific survival (BCSS) ($p < 0.05$). Adjuvant chemotherapy did not improve OS or BCSS. [33]

In all series, > 50% of these tumors are classified as TN, appear to have a favorable prognosis with low rates of nodal involvement, and are seen in women age > 50 [34–38]. In NCDB analyses of TNBCs with varying pathological subtypes, ACC consistently had a significantly improved overall survival compared to non-ACC TNBC [9, 24] with 5-year overall survival rates estimated at 88.4% (all stages combined). When examining OS for all patients with ACC, researchers using the California Cancer Registry identified an OSS rate of 95.6% at 5 years and 94.9% at 10 years [36]. While a very rare and understudied pathology, ACC appears to have quite favorable outcomes – even amongst those with TN disease.

Signet Ring Cell Breast Carcinoma (SRCBC)

Signet ring cell breast carcinoma was first described in the 1970s as subtype of invasive lobular carcinoma (ILC) and was re-classified by the WHO has a unique form of breast cancer pathology in 2003 [39]. This entity is classified histologically as having the presence of intracytoplasmic, mucin rich values in $\geq 20\%$ of the cells which attribute a signet ring shape to the cell. These tumors can sometimes be mistaken for metastasis from other organ sites, such as gastrointestinal signet ring cell carcinoma; however, SRCBC is typically keratin 7-positive and keratin 20-negative and these stains, along with ER-staining and other breast-specific markers, can be supportive of a SRCBC diagnosis [40]. (Figure 1D.) Currently, the WHO includes SRCBC as a morphologic pattern of ILC. Other ILC patterns include the histiocytoid, solid and alveolar-lobular patterns.

Similar to other subtypes, data for SRCBC consists of mostly case reports and small institutional series. The largest retrospective study identified 324 cases of SRCBC in the NCDB from.

2004–2016, representing only 0.01% of all breast carcinomas diagnosed during that time [39]. Most tumors in this series were higher grade and approximately 35% of patients had Stage IV disease at the time of diagnosis, indicative of the aggressive nature of this rare variant [39]. Previous retrospective series found 7-year disease-specific mortality rates to be as high as 70% for patients diagnosed with SRCBC but with worse outcomes for those with Stage IV disease [41–43]. Patients in the NCDB series with ER-positive disease had improved OS compared to those with ER-negative disease; however, receipt of adjuvant endocrine therapy for those with ER + disease was surprisingly not associated with a survival benefit – questioning whether this was endocrine resistance, lack of compliance, or other factors [39].

Tall Cell Carcinoma with Reversed Polarity

Tall cell carcinoma with reversed polarity of the breast (TCCRP) is a recently described TNBC with less than 100 reported cases in the literature as of August 2023 [44]. Previously, it was thought to be a variant of papillary carcinoma but was classified as a specific breast carcinoma pathology by the WHO in recent years. Histologically, it resembles the tall cell variant of papillary thyroid carcinoma but is a primary breast carcinoma and, as such, is negative for typical thyroid immunohistochemical markers such as thyroglobulin and thyroid transcription factor 1 (TTF-1) [45–47]. It is characterized by columnar cells

with reversed nuclear polarity (the nuclei are present at the apical poles instead of basal) arranged in a solid, papillary pattern [48]. While the etiology of TCCRP is unclear, it is hypothesized that these lesions may originate from intraductal papillomas or other papillary lesions of the breast. (Figure 1E.) TCCRP frequently harbor *IDH2* p.Arg172 hotspot mutations [49].

Most cases of TCCRP have been seen in post-menopausal women and is usually detected as a mass on breast imaging [31, 48, 50]. Over two-thirds of those described in the literature are TNBC; however, like other rare forms of TNBC, TCCRP has a more favorable prognosis [51, 52]. Limited data exists on this breast cancer subtype and future cohort studies are needed to further describe prognosis and clinical outcomes for patients diagnosed with this disease.

Metaplastic Breast Carcinoma

Metaplastic breast carcinoma (MBC) was first recognized as a unique histologic subtype in 2001 [53], at which time specific diagnosis codes were also created distinguish it from other grouped entities like breast sarcomas [54]. Metaplastic carcinomas are a group of invasive tumors with heterogeneity and differentiation toward metaplastic components [55]. Subtypes described by the latest World Health Organization (WHO) include low grade adenosquamous, fibromatosis-like metaplastic (low nuclear grade), squamous cell, spindle cell (intermediate to high nuclear grade) (Fig. 1F.), and carcinoma with heterologous mesenchymal differentiation [56, 57]. (Figure 1G.)

MBC is exceedingly rare, accounting for approximately only 0.25%–1% of breast cancer diagnoses [58]. In general, MBC differs from classic IDC in that patients present with larger primary tumors secondary to rapid growth rate. While only 5.3% of IDC are over 5 cm, > 20% of MBC are > 5 cm at diagnosis. Many (> 90%) of metaplastic carcinomas are TN, supporting their classification among basal carcinomas [59]. These aggressive tumors portend a worse prognosis than non-metaplastic breast cancers (78% vs 93%, $p < 0.0001$) [57].

In a NCDB series, 892 patients with MBC were identified from 2001–2003 and compared to > 200,000 patients with IDC [54]. The analysis showed that MBC is more commonly diagnosed in African American and Latinx women and despite higher AJCC stage (due to larger tumor size) MBC had a lower incidence of axillary lymph node involvement, with hematogenous spread being more common [61, 62]. While these tumors are traditionally chemoresistant, SEER analysis of 2412 patients demonstrated use of chemotherapy was associated with improved OS in non-metastatic MBC [53, 62, 63]. Outcomes have improved with multimodal treatment, but the overall

survival remains poor [64]. Similar results were shown by Nelson et al. who also evaluated survival outcomes after 10 years of available data. In this matched cohort study using SEER, patients with MBC had significantly worse disease specific survival rates than patient with IDC (78% vs 93%, $p < 0.001$) [60].

Neuroendocrine Breast Carcinoma

Primary neuroendocrine neoplasms (NEN) of the breast are rare, accounting for 0.1–1% of all breast cancers. NEN were recognized as a distinct clinical and histopathological entity in 2003 [65]. These are subdivided into two groups: well-differentiated neuroendocrine tumors (NET) and poorly differentiated neuroendocrine carcinoma (NEC). Neuroendocrine carcinoma (NEC) is characterized by high-grade neuroendocrine morphologic features and immunophenotype and include small cell and large cell variants [66, 67]. In addition to distinct morphological features, these tumors must express markers such as chromogranin A and synaptophysin in > 50% of tumor cells [68]. (Figure 1H.) Both subtypes often demonstrate areas of necrosis and a high mitotic count but have been reported to be ER+ in up to 50% of cases. [69, 70]. These tumors are also less likely to be hormone receptor positive or HER2 positive [71].

Due to their rarity, NECs have traditionally been treated like ductal or lobular carcinomas. Martinez et al. completed the largest study to date using the NCDB. They compared 1389 NEN to a matched IDC cohort and found that NEN patients were treated with surgery and radiotherapy less often than patients with IDC but received systemic treatment more often [72]. Specifically, patients with NEC seem to garner most benefit from systemic therapy while NET show little difference in survival [71]. Yang et al. found similar results with NEN patients presenting at slightly younger age than those with IDC, higher histologic grade, and at higher clinical stage with > 10% presenting with Stage IV disease.

Information on specific systemic chemotherapy regimens is limited, but Chai et al. noted that NEN patients who received chemotherapy with anthracycline/taxane and or taxane-containing regimens had better OS and DFS than those without those regimens [73]. Patients with NEN have significantly worse overall survival than patients with IDC. The prognostic relevance of NEN remains controversial with several series showing worse clinical outcome [72, 74, 75], but others that show similar outcomes to IDC [76, 77]. Despite growing research in this area using somatostatin analogs and anti-angiogenic agents, no clear treatment protocol currently exists.

Tubular Breast Carcinoma

Tubular breast carcinomas (TC) are a variant of invasive ductal carcinoma characterized by well-formed tubular glandular structures that mimic normal mammary glands. TC account for approximately 1–2% of all breast carcinomas [78] and is a low-grade carcinoma defined by $\geq 90\%$ simple, angulated tubules lined by a single layer of neoplastic epithelium with prominent apical tufts with infiltrative growth and associated desmoplastic stroma. (Figure 1I.)

TC has been associated with several precursor lesions, namely the “Rosen triad” of TC, lobular neoplasia, and columnar cell lesions. In a study of 147 tumors, columnar cell lesions (e.g., flat epithelial atypia) and atypical ductal hyperplasia (ADH)/ductal carcinoma in situ (DCIS) have been seen together with TCs in 95% and 89% of cases [79]. The presence of these associated lesions suggests possible biologic progression from these lesions [80].

Tubular cancers are diffusely ER positive, most often PR positive, and HER2 negative [81]. They are generally well-differentiated, early stage, node negative, with favorable biologic behavior, leading to overall good prognosis [82–84]. The incidence of metastasis is much lower than for IDC, ranging from 8–20% and the overall survival remains excellent even if metastasis occurs. Local and distant disease recurrence are also uncommon [85]. Treatment for tubular carcinoma is largely guided by tumor receptor status, following current protocols for HER2+ breast cancer. The surgical approach remains similar to IDC, but the importance of axillary staging remains controversial as many patients present with early stage, node negative disease. Knappe et al. suggest that SLNB could be omitted in select postmenopausal women with early stage, ER/PR+HER2-, special histologic subtype, such as tubular carcinoma [86]. Per the NCCN, adjuvant endocrine therapy is standard for patients with tumors > 3 cm and/or nodal positivity, but not routinely recommended for patients with tumors < 3 cm with node-negative disease, leaving room for multidisciplinary decision making [87]. Adjuvant systemic chemotherapy can be considered for patients with node positive disease, though its efficacy remains unclear, and most providers report not offering it given the overall good prognosis of this subtype [85, 88]. Turashvili et al. explored the use 21-gene recurrence score (RS) in rare histologic subtypes. They included 10 patients with tubular carcinoma, with a median RS of 14 (range 9–23). This suggest that reflex RS testing may be deferred in subtypes with favorable histology [89].

Mucinous Breast Carcinoma

There is a spectrum of mucinous containing breast lesions that range from benign to malignant, often making the diagnosis challenging on core biopsy. For the purposes of this review, we will focus on mucinous carcinoma (2–4%

of all breast cancers) but recognize that there are other malignant mucinous lesions such as mucinous ductal carcinoma in situ, mucinous cystadenocarcinoma, mucoepithelioid type lesions, all differentiated by varying amounts of extracellular and/or intracellular mucin [90, 91]. Mucinous carcinoma is characterized by epithelial cells suspended in abundant extracellular mucin. The epithelial cells may vary in size, shape, and nuclear atypia; but are predominantly low to intermediate in grade [92, 93]. Pure mucinous carcinoma requires $\geq 90\%$ of the tumor to exhibit mucinous features, while mixed is classified from 10 to $< 90\%$. (Figure 1J.) Pure mucinous carcinoma is typically ER/PR+, and HER2-. These tumors are generally diagnosed in peri/postmenopausal women, are low grade, and node negative [94].

The distinction between pure and mixed subtypes is important as it informs treatment. Patients with mixed mucinous tumors should be managed similar to other patients with IDC. Per NCCN guidelines, sub-centimeter pure mucinous ER/PR+ tumors without nodal involvement can be treated with surgery alone with omission of endocrine therapy [95]. Lymph node metastasis can occur and are more often seen in mixed type, but less frequently than is seen in invasive ductal carcinoma [96]. Overall, they have a good prognosis with a 10-year survival of 90% for pure mucinous carcinomas [97]. Mixed type mucinous carcinoma tends to carry a worse prognosis, with more frequent nodal involvement and surgery with or without adjuvant chemotherapy remains the mainstay of treatment [98].

Papillary Breast Carcinoma

Papillary carcinomas were initially differentiated from benign papillomas of the breast in 1962 by Kraus and Nubecker [99, 100]. Papillary carcinomas of the breast are uncommon, representing approximately 0.5% of newly diagnosed cancers [101]. Like other subtypes, there are several distinct lesions within papillary carcinomas including 1) encapsulated papillary carcinoma (EPC) (Fig. 1K.), 2) solid papillary carcinoma (SPC) (Fig. 1L.), and 3) invasive papillary carcinoma, and all share an arborescent growth pattern [102, 103]. EPCs are well-circumscribed masses within cystic spaces with pushing growth surrounded by a fibrous border, while SPCs demonstrate a solid growth pattern of rounded nests within fibrotic stroma. Both EPC and SPC, when showing well-structured, circumscribed patterns of growth are classified as in situ lesions (i.e., a variant of DCIS) by the WHO (as of the 5th edition) [104]. Papillary carcinoma can rarely show infiltrative growth; when papillary features

comprise $> 90\%$ of the tumor, the carcinoma is classified as invasive papillary carcinoma per WHO classification (5th edition) [104]. More often EPC or SPC is associated with more common subtypes of invasive carcinoma, most frequently ductal but also lobular and mucinous types. In these scenarios, infiltrative growth is what drives the stage. For example, if SPC with a morphologically in situ growth pattern extends over a greater extent but there is an associated microinvasive ductal component, the stage would be pT1mi based on the component of invasion. For invasive papillary carcinoma, the entire tumor would be classified as invasive and pT stage assigned accordingly (e.g., 1.3 cm would be pT1c). Papillary carcinomas are usually low to intermediate grade and may be positive for neuroendocrine markers (synaptophysin, chromogranin, etc. [102]).

They are often seen in elderly women (mean of 70 years of age), and largely centrally located [102, 103]. Interestingly, papillary carcinomas are the most common unique subtype found in men. A study performed using the California Cancer Registry found that papillary subtypes were more commonly diagnosed in men in that series [105, 106]. It can present clinically with bloody nipple discharge, a palpable mass or simply seen as a radiologic abnormality [101].

Most papillary carcinomas are ER/PR+, thus portending a favorable prognosis; however, some are high grade and ER/PR- [103]. Axillary staging may be omitted for pure in situ EPCs/SPCs in the setting of breast conservation surgery. High grade EPCs/SPCs should be treated as invasive disease [106, 107]. Previous literature has found that papillary carcinoma has a better prognosis than IDC, though this is based on smaller retrospective studies [108, 109]. Huang et al. used the NCDB to evaluate 1,147 patients with papillary carcinoma compared to $> 200,000$ patients with IDC and found no difference in survival between papillary carcinoma and IDC, suggesting a similar prognosis [111]. Additional notable findings were that patients with papillary carcinoma were less likely to receive adjuvant chemotherapy or radiation, but rates of endocrine therapy were similar.

Conclusion

This review demonstrates the heterogeneity of breast cancer, particularly those beyond ductal and lobular histologies. The various breast cancer subtypes discussed here have not only distinct histological findings but have unique behaviors that directly impact treatment plans for patients. However, given their rarity, evidence-based treatment protocols are scarce. There is no one size fits all approach to breast cancer treatment, and this will be increasingly true as more is learned about breast cancer biology, anthropology, and the goals and advances of emerging precision medicine [109].

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Declarations

Competing interests The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Conflict of Interest The authors declare that they have no conflict of interest.

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- Of importance
- Of major importance

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