Type 2 Dynamic Curves: A Diagnostic Dilemma

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Abstract

Objectives: Type 2 dynamic contrast-enhancement curves on breast magnetic resonance imaging (MRI) represent an intermediate kinetic pattern that often creates diagnostic uncertainty due to considerable overlap between benign and malignant lesions. This study aimed to analyze the histopathological outcomes of breast lesions demonstrating a Type 2 curve and to assess whether combining kinetic and morphological features improves diagnostic accuracy.

Methods: A retrospective review was performed on 644 dynamic contrast-enhanced breast MRI examinations conducted between January 2022 and January 2023. 32 lesions in 27 patients that exhibited a Type 2 kinetic curve and had available histopathological data were included. All lesions were reassessed by two experienced radiologists, curve types were verified using region of interest analysis, and lesions were categorized according to Breast Imaging Reporting and Data System (BI-RADS) morphology. Sensitivity and specificity values were calculated for the Type 2 curve alone and in combination with BI-RADS categories.

Results: Among the 32 lesions, 72.7% were malignant and 27.3% were benign. The most common benign lesion was sclerosing adenosis, while invasive ductal carcinoma was the most frequent malignant diagnosis. When evaluated alone, the Type 2 kinetic pattern demonstrated limited sensitivity (33.1%) and moderate specificity (72.7%) for predicting malignancy. However, diagnostic performance increased markedly when morphological assessment was incorporated. BI-RADS 4 lesions showed a malignancy rate of 68.8%, and all BI-RADS 5 lesions were malignant, yielding a positive predictive value of 100%. Combining dynamic curves with BI-RADS morphology produced significantly higher sensitivity and specificity compared with relying on kinetic patterns alone.

Conclusion: A substantial proportion of breast lesions demonstrating a Type 2 dynamic curve were malignant, indicating that this intermediate kinetic pattern should be interpreted with caution. Because Type 2 curves may also occur in benign lesions, they should not be used in isolation for diagnostic decision-making. Larger, preferably prospective studies are needed to clarify the clinical significance of Type 2 curves in breast MRI.

Keywords: BI-RADS-2 lesions, Type 2 kinetic pattern, benign, malign lesion

Introduction

Breast magnetic resonance imaging (MRI) is a non-invasive imaging modality with high sensitivity for detecting breast cancer.[1] It is used in patients with dense breast tissue when mammography is insufficient, for evaluating multifocal or multicentric masses, for preoperative surgical planning, for monitoring response to neoadjuvant chemotherapy, for assessing malignancy in the contralateral breast, and for postoperative follow-up.[1] In addition to providing morphological information about lesions, breast MRI also allows the evaluation of perfusion and enhancement characteristics through kinetic (time-signal intensity) curves obtained via dynamic contrast-enhanced imaging.[2] In this technique, an intravenous gadolinium-based contrast agent is administered to assess the lesion's enhancement and washout characteristics, thereby aiding in differentiating cancerous from normal breast tissue.[2]

The obtained dynamic contrast-enhancement curves can be categorized into three types: Type 1 (persistent), Type 2 (plateau), and Type 3 (wash-out).[3] In the literature, Type 1 curves are generally associated with benign masses, whereas Type 3 curves are more suggestive of malignancy.[3] However, Type 2 curves show substantial overlap between benign and malignant pathologies.[2,4]

Therefore, to determine the diagnostic value of Type 2 dynamic curves on breast MRI, this study examined the histopathological results of lesions demonstrating such curves.

Methods

Patient and Data Selection

Dynamic contrast-enhanced breast MRI examinations performed on 644 patients between January 2022 and January 2023 were retrospectively reviewed. Among these, 45 lesions in 38 patients demonstrated a Type 2 curve. Seven patients and eight lesions were excluded because of prior radiotherapy, prior surgery or biopsy, poor image quality, or unavailable histopathological data. Ultimately, 27 patients and 32 lesions were included in the study.

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Imaging and Evaluation

All lesions were re-evaluated by two experienced radiologists. Curve types were confirmed using region of interest -based analysis of dynamic contrast images. Lesions were classified according to Breast Imaging Reporting and Data System (BI-RADS) MRI criteria.[3] Histopathological data were obtained retrospectively from the hospital information system.

Imaging Protocol

A 1.5-Tesla MRI scanner with a 4-channel dedicated breast coil was used. Standard T2-weighted and 3D T1-weighted sequences were acquired. Gadolinium-based contrast material (0.1 mmol/kg) was administered intravenously, followed by dynamic post-contrast imaging and morphological assessment according to established breast MRI protocols.[1,5]

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences software version 20.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means ± standard deviations. Receiver operating characteristic analysis and chi-square tests were applied. A p value 0.05 was considered statistically significant.

The study was conducted with approval from the Erzincan Binali Yıldırım University Non-Interventional Clinical Research Ethics Committee (decision no: 2023-01/01, date: 03.01.2023).

Results

The mean age of the 27 patients included in the study was 49.9±10.1 years (range: 43-85 years). All 32 lesions demonstrated a Type 2 curve. Of these lesions, 9 (27.3%) were benign and 23 (72.7%) were malignant. The most common benign and malignant diagnoses were sclerosing adenosis (25%) and invasive ductal carcinoma (43.8%), respectively (Table 1).

When the morphological BI-RADS categories of lesions demonstrating a Type 2 kinetic curve were evaluated (Table 2), 6 lesions were classified as BI-RADS 3 (18.8%), 16 as BI-RADS 4 (50.0%), and 10 as BI-RADS 5 (31.2%). All 6 lesions in the BI-RADS 3 category were consistent with benign pathology. Among the 16 BI-RADS 4 lesions, 11 (68.8%) were malignant and 5 (31.2%) were benign. All 10 lesions categorized as BI-RADS 5 were concordant with malignant findings on histopathology.

When the dynamic contrast-enhancement curve type was compared with the histopathological results, the sensitivity of a Type 2 curve for predicting malignancy was 33.1%, and specificity was 72.7%. Evaluation based solely on the kinetic curve pattern was limited in its ability to detect malignant lesions. However, diagnostic performance increased markedly when a Type 2 curve was combined with morphological assessment findings. In particular, when the lesion's BI-RADS category was considered, the sensitivity and specificity increased significantly (Table 3). Similarly, when only BI-RADS 5 lesions with a Type 2 curve were classified as malignant, no false-positive results were observed in our study; the positive predictive value was 100%, because all such lesions were truly malignant.

Table 1. Histopathological findings of lesions demonstrating Type 2 dynamic curves (n=32)

Histopathological diagnosis	n (%)
Sclerosing adenosis	8 (25%)
Fibroadenoma	1 (3.1%)
Intraductal papilloma	0 (0.0%)
Benign (total)	**9 (27.3%)**
Ductal carcinoma in situ	5 (15.6%)
Invasive ductal carcinoma	14 (43.8%)
Invasive lobular carcinoma	4 (12.5%)
Malignant (total)	**23 (72.7%)**
Total	**32 (100%)**

Table 2. Distribution by BI-RADS category (n=32)

BI-RADS category	Lesion count	(%)	Malignant (n)	Malignancy rate (%)
BI-RADS 3	6	18.8	0	0.0
BI-RADS 4	16	50.0	11	68.8
BI-RADS 5	10	31.2	10	100.0
Total	**32**	**100**	**21**	**65.6**

BI-RADS: Breast Imaging Reporting and Data System

Table 3. Diagnostic performance with addition of morphologic features in lesions showing Type 2 dynamic curve

Evaluation method	Sensitivity (%)	95% CI	Specificity (%)	95% CI
Type 2 curve only	35.2	15.4-54.2	69.5	35.9-97.5
Type 2 curve + BI-RADS 3	37.3	19.2-59.0	72.9	50.7-100
Type 2 curve + BI-RADS 4	89.5	79.8-100	91.6	68.4-100
Type 2 curve + BI-RADS 5	100	85.5-100	100	68.2-100

Confidence intervals were calculated using the Wilson method. Sensitivity and specificity calculations were performed on 23 malignant and 9 benign lesions, respectively
BI-RADS: Breast Imaging Reporting and Data System, CI: Confidence interval

Discussion

Type 2 curves obtained on dynamic contrast-enhanced breast MRI are considered an intermediate enhancement pattern between benign and malignant lesions, often causing diagnostic uncertainty.[3] In our study, 68.6% of lesions with a Type 2 dynamic curve were malignant on histopathology, which is higher than the rates reported in previous studies.[4,5]

Several studies have reported that the sensitivity of a Type 2 curve for detecting malignancy ranges from 30% to 45%, while specificity ranges from approximately 70% to 80%.[4,5] Our sensitivity (38.1%) and specificity (75.0%) values are consistent with these findings.

Schnall et al.[2] demonstrated that lesions with a Type 3 wash-out curve had a fivefold higher risk of malignancy compared with Type 1 curves;

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76% of Type 3 lesions were malignant. Similar conclusions have been reported in other large series, reinforcing the strong association between Type 3 curves and malignancy.[5,6] However, the diagnostic significance of Type 2 curves remains controversial.

In our study, most Type 2 curve lesions exhibited suspicious morphological features and higher BI-RADS categories, warranting biopsy. All BI-RADS 5 lesions were malignant, and approximately 70% of BI-RADS 4 lesions were malignant, consistent with previous reports.[3,7] Conversely, most BI-RADS 3 lesions were benign, but one invasive carcinoma was identified, emphasizing that malignancy cannot be completely excluded even in probably benign lesions.[4]

Among benign lesions with a Type 2 curve, sclerosing adenosis was the most frequent pathology, a finding consistent with prior literature.[8] Sclerosing adenosis is known to mimic malignancy on MRI, particularly on dynamic contrast-enhanced sequences.[8] Fibroadenomas were the second most common benign lesions and were also reported to demonstrate atypical enhancement patterns in some cases.[6]

One of the most important findings of this study is that combining kinetic curve analysis with morphological assessment significantly improves diagnostic accuracy. Reliance on kinetic curve patterns alone may lead to misinterpretation; therefore, lesion morphology, BI-RADS category, and clinical context must be considered.[3,6] Lesions with suspicious morphology (BI-RADS 4 or 5) should undergo biopsy regardless of the presence of a Type 2 curve.

Study Limitations

This was a single-center, retrospective study with a relatively small sample size (n=35 lesions). Histopathological outcomes were evaluated on a lesion-by-lesion basis; thus, the number of lesions exceeded the number of patients because some patients had more than one lesion. Due to the retrospective design, selection bias may have been present in the collected data. Because the study focused exclusively on lesions exhibiting a Type 2 kinetic curve, most malignant lesions in the general population, which typically demonstrate a Type 3 curve, were not considered in this investigation. Nevertheless, the aim of this study was to examine in detail the small subset of malignant lesions that present with a Type 2 curve. Finally, the interpretation of dynamic curve patterns may be somewhat subjective. Although two experienced radiologists evaluated the lesions by consensus, minor interobserver variations remain possible (Figure 1).
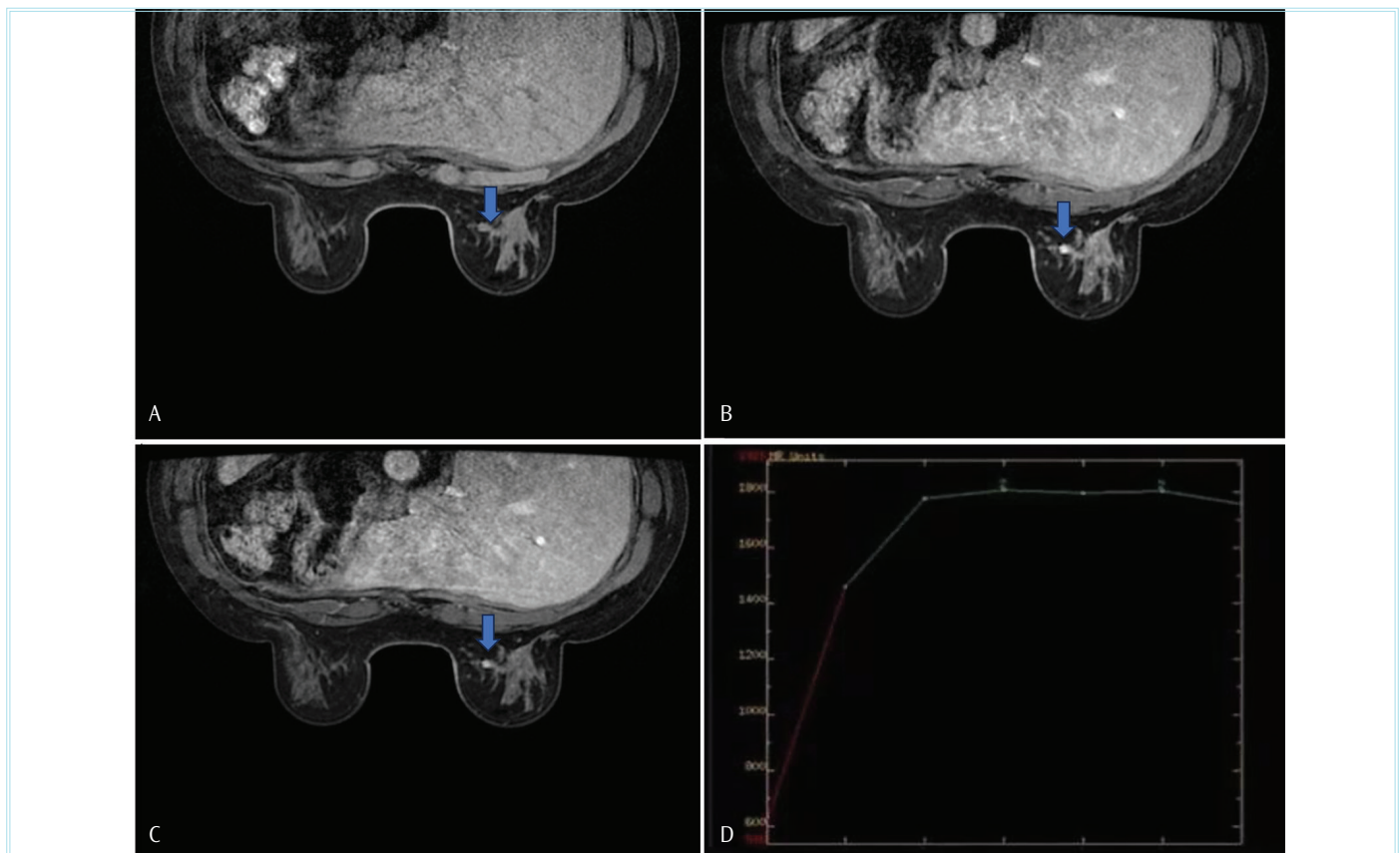
Figure 1. Example of a malignant lesion demonstrating a Type 2 contrast-enhancement kinetic curve

In the dynamic breast MRI assessment, the lesion measuring approximately 10 mm and located in the lower inner quadrant of the right breast (A, B, C) exhibits a smooth and persistent enhancement pattern, without evidence of washout. The contrast-enhancement remains stable over time, corresponding to a Type 2 (plateau) kinetic curve, as illustrated in panel (D). Histopathological analysis subsequently confirmed the lesion to be invasive breast carcinoma

MRI: Magnetic resonance imaging

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Conclusion

A considerable proportion of breast lesions demonstrating a Type 2 dynamic contrast enhancement curve were malignant. Although Type 2 curves may also be seen in benign lesions, they should not be regarded as reassuring findings. Morphological features and BI-RADS categorization remain essential for accurate diagnosis, and biopsy should not be delayed when clinically indicated. The combination of kinetic and morphological MRI assessments enhances diagnostic performance. Larger prospective studies are needed to further clarify the clinical significance of Type 2 enhancement curves.

Ethics

Ethics Committee Approval: The study was conducted with approval from the Erzincan Binali Yıldırım University Non-Interventional Clinical Research Ethics Committee (decision no: 2023-01/01, date: 03.01.2023).

Informed Consent: Since the study was a retrospective study, informed consent was not required by the ethics committee.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.K.Ö., O.T., Concept: H.K.Ö., O.T., Design: H.K.Ö., O.T., Data Collection or Processing: H.K.Ö., O.T., Analysis or Interpretation: O.T., Literature Search: H.K.Ö., O.T., Writing: H.K.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

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