

乳腺三维断层摄影与乳腺彩超在乳腺疾病诊断中的效能对比

姚苗苗,蔡思清,黄雪清,吴培丽,颜建湘,蔡冬鹭,黄美铃,林鲤玲
福建医科大学第二临床医学院影像学教研室,福建 泉州 362001

【摘要】目的:研究数字乳腺三维断层技术(DBT)和乳腺超声在诊断乳腺病变效能的不同以及联合应用对于乳腺诊断的价值。**方法:**收集1 065例乳腺病变患者,其中333例有完整的病理检查资料。以乳腺影像报告和数据系统(BI-RADS)分类为标准,分析DBT、超声、DBT+超声在乳腺病变诊断中的分布差异。根据333例病理结果,比较3种诊断模式的诊断效能。**结果:**DBT与超声的BI-RADS分布有显著性差异($P=0.001$),DBT与DBT+超声或超声与DBT+超声的BI-RADS分布无显著性差异($P=0.258, 0.394$)。3种诊断模式均可明显区分恶性和良性乳腺病变($P<0.001$)。多组独立样本Kruskal-Wallis秩和检验分析显示3种诊断模型存在差异($\chi^2=14.982, P=0.001$)。DBT的特异性、误诊率、准确性和阳性预测值明显优于超声。超声显示囊性病变优于DBT,且超声对确定良性肿块敏感性优于DBT。DBT+超声的特异性为99.5%,误诊率为0.5%,阳性预测值也达到99%。DBT+超声的检查模式优于单独使用DBT或超声。**结论:**与单独的DBT或超声相比,DBT和超声的组合可以提高乳腺病变的诊断效能。

【关键词】数字乳腺三维断层技术;彩超;乳腺影像报告和数据系统;乳腺疾病;诊断效能

【中图分类号】R445.4

【文献标志码】A

【文章编号】1005-202X(2018)12-1430-06

Comparison of the efficacy of digital breast tomosynthesis and color Doppler ultrasound in the diagnosis of breast diseases

YAO Miaomiao, CAI Siqing, HUANG Xueqing, WU Peili, YAN Jianxiang, CAI Donglu, HUANG Meiling, LIN Liling
Department of Imaging, the Second Clinical College of Fujian Medical University, Quanzhou 362001, China

Abstract: Objective To compare the efficacy of digital breast tomosynthesis (DBT), color Doppler ultrasound, and DBT+color Doppler ultrasound for the diagnosis of breast lesions. **Methods** Among the 1 065 patients with breast lesions enrolled in this study, 333 cases had complete pathological examination data. Using breast imaging reporting and data system (BI-RADS) classification as the criterion, the distribution differences among DBT, ultrasound, and DBT+ultrasound in diagnosis of breast lesions were analyzed. Based on the pathological results of 333 cases, the diagnostic efficacies of 3 diagnostic models were compared. **Results** There were significant differences in BI-RADS distribution between DBT and ultrasound ($P=0.001$), and no significant differences were found between DBT and DBT+ultrasound or between ultrasound and DBT+ultrasound ($P=0.258, 0.394$). All 3 diagnostic models distinctly discriminated the malignant and benign breast lesions (all $P<0.001$). The analysis with multi-group independent-sample Kruskal-Wallis test showed that there were differences among 3 diagnostic models ($\chi^2=14.982, P=0.001$). DBT was superior to ultrasound in the specificity, misdiagnosis rate, accuracy and positive predictive value. Ultrasound was better than DBT in displaying the cystic lesions, and the sensitivity of ultrasound in determining benign masses was higher than that of DBT. The specificity, misdiagnosis rate and positive predictive value of DBT+ultrasound were 99.5%, 0.5% and 99%, respectively. The combined use of DBT and ultrasound was better than using DBT or ultrasound alone in the diagnosis of breast diseases. **Conclusion** Compared with using DBT or ultrasound alone, the combination of DBT and ultrasound can improve the diagnostic efficacy of breast lesions.

Keywords: digital breast tomosynthesis; color Doppler ultrasound; breast imaging reporting and data system; breast disease; diagnostic efficacy

【收稿日期】2018-06-24

【基金项目】福建省卫生计生委医药卫生科技创新项目(2015-CX-28)

【作者简介】姚苗苗,研究方向:乳腺放射诊断,E-mail: 1924400951@qq.com

【通信作者】蔡思清,副教授,主任医师,研究方向:乳腺放射诊断,E-mail: 1920455696@qq.com

前言

乳腺癌是导致全世界女性死亡和患病的主要原因,也是女性最常见的恶性肿瘤^[1]。因此乳腺癌筛查越来越受到社会的认可和重视。在乳腺病变的筛查

中,数字乳腺三维断层技术(Digital Breast Tomosynthesis, DBT)及超声在乳腺病变的发现和诊断过程中发挥着重要作用。文献[2]证实可以通过DBT及超声检查降低乳腺癌患者的死亡率。本研究比较了3种诊断模型(DBT、超声、DBT+超声)对乳腺影像报告和数据系统(BI-RADS)分类和诊断效能的分布,并分析了它们的优点,为进一步应用DBT和超声诊断乳房病变提供参考。

1 资料与方法

1.1 病例资料

回顾性分析2013年5月~2015年7月在福建医科大学附属第二临床医学院就诊的1 065例患者,年龄25~85岁,平均年龄(42.01±8.85)岁。

入选条件为所有病例术前均行乳腺超声及DBT检查,其中有333例行乳腺手术切除,均经手术病理证实,并将其分为良性组及恶性组,良性组211个病灶,恶性组122个病灶。

1.2 设备与方法

1.2.1 设备 美国Hologic公司生产的Selenia® Dimensions®数字乳腺三维断层摄影系统以及彩色多普勒超声设备(日立HITACHI二郎神彩超机)。

1.2.2 方法 所有患者均摄头尾位(Craniocaudal, CC)及内外斜位(Mediolateral Oblique, MLO),每次DBT球管在15°内转动,每转1°曝光一次,共获得15帧图像,然后在此基础上将图像重建成一系列高分辨率的断层影像,同时获得全数字化成像(Full-Field Digital Mammography, FFDM)及DBT图像,这两种图像结合为COMBO模式。由专门从事超声工作4年以上医生完成所有患者的超声检查。

分别记录1 065例病人的DBT及超声检查结果,以BI-RADS分类诊断为标准,分析两种检查方法对乳腺病灶BI-RADS分类诊断的分布差异,同时分析对333例有病理结果的病例应用DBT和超声两种检查方法的诊断效能。由4名医师对每个病例进行集体阅片,并得出一致结论。

1.3 统计学分析

应用SPSS 20.0统计学软件进行分析。以BI-RADS分类诊断为标准,应用Wilcoxon配对符号秩和检验分析DBT、超声、DBT+超声这3种模式对乳腺病灶BI-RADS分类诊断的分布差异。以病理诊断为标准,采用受试者工作特征(Receiver Operating Characteristic, ROC)曲线,对3种模式的诊断效能进行对比,多组独立样本采用Kruskal-Wallis秩和检验。 $P<0.05$ 被认为具有统计学差异。

2 结果

2.1 诊断模式的诊断分布及比较结果

对1 065例患者分别进行DBT、超声及DBT+超声模型的诊断,此3种诊断模式的BI-RADS分类的诊断分布如表1所示。3种诊断模型的两两比较结果如表2所示。DBT和超声之间BI-RADS分布有显著差异($P=0.001$),DBT和DBT+超声之间($P=0.258$)及超声和DBT+超声之间分布无显著差异($P=0.394$)。多组独立样本Kruskal-Wallis秩和检验的分析显示 $\chi^2=14.982$ 和 $P=0.001$,表明3种诊断模型之间存在差异。

表1 DBT、超声以及二者结合的诊断模式BI-RADS分类的诊断分布[例(%)]

Tab.1 BI-RADS classification in 3 diagnostic models [cases(%)]

BI-RADS grade	DBT	Ultrasound	DBT+Ultrasound
0	28(2.63)	2(0.19)	1(0.09)
1	4(0.38)	21(1.97)	4(0.38)
2	481(45.16)	310(29.11)	443(41.60)
3	213(20.00)	388(36.43)	268(25.16)
4A	97(9.11)	178(16.71)	117(10.99)
4B	134(12.58)	93(8.73)	123(11.55)
4C	54(5.07)	38(3.57)	50(4.69)
5	54(5.07)	35(3.29)	59(5.53)
Total	1 065(100)	1 065(100)	1 065(100)

BI-RADS: Breast imaging reporting and data system; DBT: Digital breast tomosynthesis

表2 3种模式BI-RADS分类的诊断分布两两比较结果如下

Tab.2 Pairwise comparison of BI-RADS classification in 3 diagnostic models

Diagnostic model	χ^2 value	P value
DBT versus DBT + ultrasound	-77.526	0.258
DBT versus ultrasound	-148.012	0.001
Ultrasound versus DBT + ultrasound	70.486	0.394

2.2 不同模式的诊断效能

2.2.1 3种模式的ROC曲线 3种模式的诊断结果与病理结果的比较见表3,并分别构建3种诊断模式的ROC曲线(图1),计算曲线下面积(AUC)。DBT诊断乳腺恶性肿瘤时,AUC为0.923,95%CI为0.890~0.956,敏感度为77.9%,特异度为98.1%;超声诊断乳腺恶性肿瘤时,AUC为0.868,95%CI为

0.823~0.912, 敏感度为 82.0%, 特异度为 82.9%; 为 0.942~0.985, 敏感度为 82.0%, 特异度为 99.5%。
DBT+超声诊断恶性肿瘤时, AUC 为 0.964, 95%CI

表3 3种模式的诊断结果与病理结果的比较[例(%)]

Tab.3 Comparison of diagnostic results and pathological results of 3 diagnostic models [cases(%)]

Diagnostic model	Diagnosis result	Pathological result		Total	χ^2 value	P value
		Malignant	Benign			
DBT	Malignant	95(77.9)	4(1.9)	99(29.7)	213.577	<0.05
	Benign	27(22.1)	207(98.1)	234(70.0)		
	Total	122(100.0)	211(100.0)	333(100.0)		
Ultrasound	Malignant	100(82.0)	36(17.1)	136(40.8)	134.786	<0.05
	Benign	22(18.0)	175(82.9)	197(59.2)		
	Total	122(100.0)	211(100.0)	333(100.0)		
DBT+ultrasound	Malignant	100(82.0)	1(0.5)	101(30.3)	242.952	<0.05
	Benign	22(18.0)	210(99.5)	232(69.7)		
	Total	122(100.0)	211(100.0)	333(100.0)		

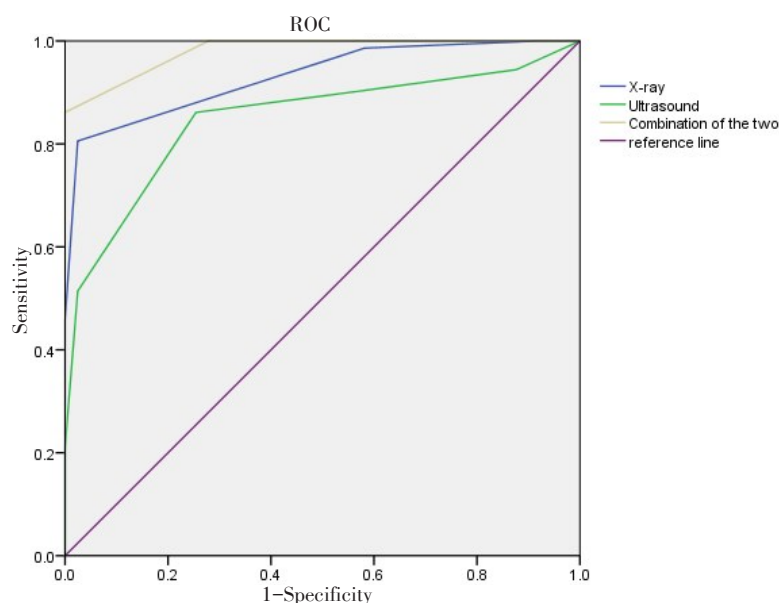


图1 DBT、超声以及DBT+超声三种模式 ROC 曲线

Fig.1 Receiver operating characteristic curves of DBT, ultrasound, and DBT+ultrasound

2.2.2 3种模式的比较 DBT+超声的检查模式更优。DBT+超声诊断乳腺恶性肿瘤的AUC值(0.964)大于DBT和超声的AUC值(0.923、0.868);DBT+超声结果的最佳截值点的特异性(99.5%)高于DBT和超声的最佳截点的特异度(98.1%、82.9%)。DBT+超声和超声的敏感度相同,均为82%,均高于DBT的敏感度(77.9%),经多组独立样本Kruskal-Wallis秩和检验,两者的差异有统计学意义($P<0.001$)。

2.3 DBT与彩超在BI-RADS分类上的优势

DBT能更精准地判断恶性钙化的形态、大小及分布,DBT图像可以减少周围腺体组织及其他正常结构的重叠干扰,显示隐藏在腺体实质中的微小钙化(图2),从而提高早期乳腺癌的检出率,有助于患者的早期治疗,但是对于部分微小簇状钙化,单独用1 mm层厚进行观察时,每层图像视野中的钙化数量可能会减少,不便于整体观察钙化的数量,此时我们要调整观察层厚或者结合FFDM进行观察。相对于超声,DBT可以更好地显示结构扭曲(图3),结构扭

般表现为无回声,容易与低回声的实性病灶相鉴别,而囊性与实性病灶在DBT上均表现为高密度使得鉴别相对困难;另外超声对于隆乳后病灶的发现也优于DBT(图5),隆乳术后行DBT检查会引起过度曝光,导致不利于观察正常腺体实质结构内的病灶,而超声可以完整地显示假体,且在行超声检查时假体对正常腺体实质内病灶的观察影响相对较小。

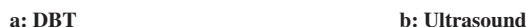


Fig.2 DBT images and ultrasound image of pathologically diagnosed ductal carcinoma *in situ*



Fig.3 DBT images and ultrasound image of pathologically diagnosed infiltrating lobular carcinoma



Fig.4 DBT images and ultrasound image of pathologically diagnosed breast cystic lesions

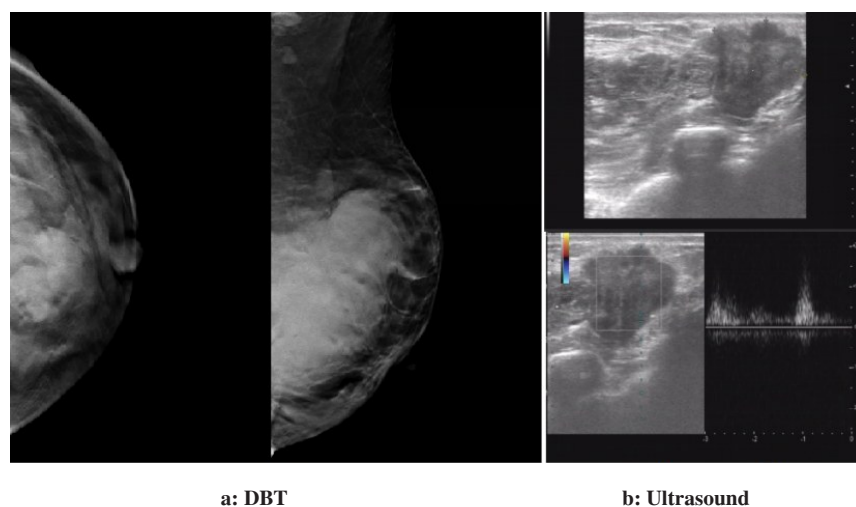


图5 病理诊断为浸润性导管癌的DBT和超声图像

Fig.5 DBT images and ultrasound image of pathologically diagnosed infiltrating ductal carcinoma

3 讨论

数字乳腺断层融合DBT成像作为一种新的成像技术,利用不同投照角度实现乳腺三维重建成像,旨在更好地显示较致密的乳腺(乳腺实质结构分类为c类及d类)中被遮蔽的小肿块、提高乳腺病灶的检出率,从而提高乳腺病灶检出敏感性和特异性^[3-4]。DBT成像方法是一项基于平板探测器技术的高级应用,通过一系列不同角度对乳腺进行快速采集,获取不同投影角度下的小剂量投影数据,重建出与探测器平面平行的乳腺任意层面图像^[5]。DBT不同于FFDM,主要差异包括扫描方式、成像角度以及参数等。使用DBT成像时,乳腺保持制动,DBT球管在一定的角度范围内(约15°)旋转,每旋转1°,低剂量曝光1次,从而得到不同角度下的乳腺投影,进而将其重建为断层影像。DBT成像方法能够解决传统二维FFDM成像的重叠问题,提高图像质量、诊断的敏感性、对肿块大小评估的准确性^[6-7]以及降低召回率^[8]。Partyka等^[9]发现DBT断层图像可以更好地显示肿块的边缘、周围的透亮环、血管影、钙化灶以及与周围相邻组织的关系等征象。同时,Amer等^[10]认为在使用DBT和FFDM技术评价肿瘤标本摄影中肿瘤边缘的可靠性时,DBT在识别肿瘤最接近的边界和灵敏度方面明显优于FFDM。虽然DBT辐射剂量也较常规FFDM有所增加,但仍均低于FDA规定的最高限值3 mGy。有学者认为,如果DBT技术能够提高诊断效能,略高的辐射剂量也是可以接受的^[11]。而对于钙化特征的显示,DBT技术无显著提高^[12-13],但是我们的前期研究显示隐藏在肿块内的微小钙化灶能在DBT下更好地显示^[14]。回顾既往相关文献报道,对

于DBT的临床研究,主要侧重于DBT与常规FFDM的对比应用研究^[15-16]。而针对诊断效能的比较研究,在早期文献中并未发现DBT与FFDM的明显差异。

近年来通过DBT结合FFDM研究分析,研究内容的不断深入以及样本量的扩大,目前大多数研究结果均显示,DBT结合FFDM较单独应用FFDM的诊断价值有所提高^[17-19],能够提高诊断的敏感性和特异性^[3-4]。有研究报道称将DBT与FFDM结合可以检测到单独使用FFDM时漏诊的浸润性乳腺癌^[20]。而且我们前期研究也显示COMBO模式下AUC及灵敏度均高于FFDM的单独应用(0.941 vs 0.805,82.9% vs 60.0%)^[14],这一结果与国外大量文献报道的结论基本一致。综上所述,DBT结合FFDM诊断具有明显提高诊断效能及肿块显示的能力^[6,21]。

本研究对DBT与乳腺彩色多普勒超声两种不同成像方式进行对照应用研究。乳腺彩色多普勒超声既具有二维超声结构图像的优点,能精确鉴别囊、实性病变,提供致密型乳腺的诊断信息,也可提供血流动力学的信息,提高超声对乳腺疾病的诊断灵敏度;同时超声兼具无放射、无痛苦、安全、重复性好、费用较低的优点,对青春女性、妊娠哺乳期女性尤为合适^[22]。但是乳腺超声主观性强、可靠性差,同时对触诊阴性乳腺癌、微小钙化、结构扭曲及不对称致密影不敏感,特异度不高。DBT成像,作为唯一被认可的乳腺普查的影像检查方法,可以敏感地探测到细小钙化,有效发现早期乳腺癌^[23],较传统FFDM更具诊断价值^[24-26]。对于0级致密型乳腺,DBT比乳腺超声表现出更好的诊断性能,DBT可降低良性病变的活检概率并减少短期随访,相比超声检查,DBT对乳腺病变诊断具有更好的价值^[27],此结论与本研究结论

有基本一致,即DBT的诊断准确性高于超声(90.7% vs 82.6%)。

另外,本研究在探索DBT特有优势的同时,创新性地将DBT与乳腺彩超两者的特点结合,进一步探索DBT结合乳腺彩超对诊断效能的影响,以期获得客观准确的诊断评估。超声与DBT结合特异性高达99.5%,误诊率为0.5%,阳性预测值也达到99%,这表明DBT+超声可以取得较好的诊断效果,既保证检出率又可提高诊断准确率,具有较高的临床推广价值。尽管如此,这项研究仍然有一些局限性。这项研究的样本量相对较小。较大的样本量将使结果更具说服力。在我们未来的研究中,样本量会进一步增加,以获得更好的结果。

【参考文献】

- [1] FIDLER M M, GUPTA S, SOERJOMATARAM I, et al. Cancer incidence and mortality among young adults aged 20-39 years worldwide in 2012: a population-based study[J]. *Lancet Oncol*, 2017, 18(12): 1579-1589.
- [2] ANDERSON B O, SHYYAN R, ENIU A, et al. Breast cancer in limited-resource countries: an overview of the Breast Health Global Initiative 2005 guidelines[J]. *Breast J*, 2010, 12(s1): S3-S15.
- [3] PISANO E D, GATSONIS C, HENDRICK E, et al. Diagnostic performance of digital *versus* film mammography for breast-cancer screening[J]. *N Engl J Med*, 2005, 353(17): 1773-1783.
- [4] BICK U, DIEKMANN F. Digital mammography: what do we and what don't we know?[J]. *Eur Radiol*, 2007, 17(8): 1931-1942.
- [5] DIEKMANN F, BICK U. Breast tomosynthesis[J]. *Semin Ultrasound CT MR*, 2011, 32(4): 281-287.
- [6] GENNARO G, TOLEDANO A, DI MAGGIO C, et al. Digital breast tomosynthesis *versus* digital mammography: a clinical performance study[J]. *Eur Radiol*, 2010, 20(7): 1545-1553.
- [7] FÖRNVIK D, ANDERSSON I, SVAHN T, et al. The effect of reduced breast compression in breast tomosynthesis: human observer study using clinical cases[J]. *Radiat Prot Dosimetry*, 2010, 139(1/3): 118-123.
- [8] POPLACK S P, TOSTESON T D, KOGEL C A, et al. Digital breast tomosynthesis: initial experience in 98 women with abnormal digital screening mammography[J]. *AJR Am J Roentgenol*, 2007, 189(3): 616-623.
- [9] PARTYKA L, LOURENCO A P, MAINIERO M B. Detection of mammographically occult architectural distortion on digital breast tomosynthesis screening: initial clinical experience[J]. *AJR Am J Roentgenol*, 2014, 203(1): 216-222.
- [10] AMER H A, SCHMITZBERGER F, INGOLD-HEPPNER B, et al. Digital breast tomosynthesis *versus* full-field digital mammography-Which modality provides more accurate prediction of margin status in specimen radiography?[J]. *Eur J Radiol*, 2017, 93: 258-264.
- [11] FENG S S, SECHOPOULOS I. Clinical digital breast tomosynthesis system: dosimetric characterization[J]. *Radiology*, 2012, 263(1): 35-42.
- [12] NOROOZIAN M, HADJIISKI L, RAHNAMA-MOGHADAM S, et al. Digital breast tomosynthesis is comparable to mammographic spot views for mass characterization[J]. *Radiology*, 2012, 262(1): 61-68.
- [13] GUR D, BANDOS A I, ROCKETTE H E, et al. Localized detection and classification of abnormalities on FFDM and tomosynthesis examinations rated under an FROC paradigm[J]. *AJR Am J Roentgenol*, 2011, 196(3): 737-741.
- [14] CAI S Q, YAN J X, CHEN Q S, et al. Significance and application of digital breast tomosynthesis for the BI-RADS classification of breast cancer[J]. *Asian Pac J Cancer Prev*, 2015, 16(9): 4109-4114.
- [15] GOOD W F, ABRAMS G S, CATULLO V J, et al. Digital breast tomosynthesis: a pilot observer study[J]. *AJR Am J Roentgenol*, 2008, 190(4): 865-869.
- [16] GUR D, ABRAMS G S, CHOUGH D M, et al. Digital breast tomosynthesis: observer performance study[J]. *AJR Am J Roentgenol*, 2009, 193(2): 586-591.
- [17] TEERTSTRA H J, LOO C E, VAN DEN BOSCH M A, et al. Breast tomosynthesis in clinical practice: initial results[J]. *Eur Radiol*, 2010, 20(1): 16-24.
- [18] SVAHN T, ANDERSSON I, CHAKRABORTY D, et al. The diagnostic accuracy of dual-view digital mammography, single-view breast tomosynthesis and a dual-view combination of breast tomosynthesis and digital mammography in a free-response observer performance study[J]. *Radiat Prot Dosimetry*, 2010, 139(1/3): 113-117.
- [19] STARIKOV A, DROTMAN M, HENTEL K, et al. 2D mammography, digital breast tomosynthesis, and ultrasound: which should be used for the different breast densities in breast cancer screening?[J]. *Clin Imaging*, 2016, 40(1): 68-71.
- [20] YUN S J, RYU C W, RHEE S J, et al. Benefit of adding digital breast tomosynthesis to digital mammography for breast cancer screening focused on cancer characteristics: a meta-analysis[J]. *Breast Cancer Res Treat*, 2017, 164(3): 557-569.
- [21] SVAHN T M, CHAKRABORTY D P, IKEDA D, et al. Breast tomosynthesis and digital mammography: a comparison of diagnostic accuracy[J]. *Br J Radiol*, 2012, 85(119): e1074-e1082.
- [22] 曹亚丽, 王国清, 吴小波, 等. 三种检查方法对乳腺疾病的诊断价值[J]. *实用癌症杂志*, 2009, 24(2): 165-167.
- CAO Y L, WANG G Q, WU X B, et al. Control study of three different examination in diagnosis of breast disease[J]. *Practical Journal of Cancer*, 2009, 24(2): 165-167.
- [23] 邓丽萍, 章士正. 乳腺磁共振成像[J]. *国外医学: 临床放射学分册*, 2003, 26(5): 317-320.
- DENG L P, ZHANG S Z. Foreign medical sciences (clinical radiology) [J]. *Foreign Medical Sciences: Clinical Radiological Fascicle*, 2003, 26(5): 317-320.
- [24] MICHELL M J, IQBAL A, WASAN R K, et al. A comparison of the accuracy of film-screen mammography, full-field digital mammography, and digital breast tomosynthesis[J]. *Clin Radiol*, 2012, 67(10): 976-981.
- [25] TAGLIAFICO A, TAGLIAFICO G, ASTENGO D, et al. Mammographic density estimation: one-to-one comparison of digital mammography and digital breast tomosynthesis using fully automated software[J]. *Eur Radiol*, 2012, 22(6): 1265-1270.
- [26] WALLIS M G, MOA E, ZANCA F, et al. Two-view and single-view tomosynthesis *versus* full-field digital mammography: high-resolution X-ray imaging observer study[J]. *Radiology*, 2012, 262(3): 788-796.
- [27] LEE W K, CHUNG J, CHA E S, et al. Digital breast tomosynthesis and breast ultrasound: additional roles in dense breasts with category 0 at conventional digital mammography[J]. *Eur J Radiol*, 2016, 85(1): 291-296.

(编辑:谭斯允)