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全数字化 X 线摄影联合 MR 动态增强检查诊断早期乳腺癌的临床价值研究

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摘要 目的:分析早期乳腺癌的全数字 X 线摄影与 MRI 影像学表现,评价全数字 X 线摄影联合 MRI 检查在早期乳腺癌诊断中的临床价值。**方法:**回顾性分析 2009 年 10 月至 2012 年 5 月在我院经穿刺或手术病理证实为早期乳腺癌的 42 例患者的临床资料,术前均行数字 X 线及动态增强 MR 检查,比较两种方法单独使用和联合使用的诊断乳腺癌的准确率。**结果:**全数字化 X 线摄片诊断早期乳腺癌的准确率为 69.0%(29/42),动态增强 MR 检查为 95.2%(40/42),两者比较差异有统计学意义($P<0.05$);两者联合使用诊断早期乳腺癌的准确率为 97.6%(41/42)。**结论:**动态增强 MR 检查对早期乳腺癌的诊断价值明显优于全数字 X 线摄影,但后者对微小钙化显示较好,两者联合可提高诊断正确率,尤其对多腺体型和致密型乳腺的早期乳腺癌的检出具有重要的价值。

关键词:早期乳腺癌;全数字化 X 线摄影;磁共振;诊断价值

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Clinical Significance of Full-field Digital Mammography Combined with Dynamic Contrast-enhanced MRI in the Diagnosis of Early Breast Cancer

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ABSTRACT Objective: To analyze the imaging features of early breast cancer by full-field digital mammography (FFDM) and magnetic resonance (MR), and study the clinical significance of mammography combined with MR in the diagnosis of early breast cancer. **Methods:** 29 patients with early breast cancer confirmed with needle biopsy or pathology from Oct. 2009 to May. 2012 were reviewed. These patients underwent both mammo and dynamic contrast-enhanced MR imaging (DCE-MRI) before operation to compare the preoperative diagnostic accuracy by using mammo and DCE-MRI each alone and in combination. **Results:** The diagnostic accuracy of mammography was 69.0%(29/42) in the diagnosis of early breast cancer, which was 95.2%(40/42) of DCE-MRI ($P<0.05$) and 97.6 % (41/42) of the combination of both methods. **Conclusion:** The diagnostic value of DCE-MRI for early breast cancer was more superior to mammo, however the latter showed better microcalcifications, combination of the two methods could increase the diagnostic accuracy, and had very important value for the detection of early breast cancer, especially for heterogeneous type and dense-type.

Key words: Breast Neoplasms; Full-field digital mammography; Magnetic Resonance Imaging; Clinical significance

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前言

乳腺癌是女性发病率较高的恶性肿瘤,2011 年美国肿瘤协会统计显示乳腺癌新发病例数占所有女性所患癌症的 30%,居首位,其死亡率仅次于肺癌^[1]。选择合适的检查方法对乳腺癌的早期诊断颇为重要。乳腺癌的检查方法很多,X 线摄影是目前的首选检查方法^[2]。近年来,磁共振成像检查技术(MRI)对乳腺癌的诊断和鉴别诊断显示出极大的优势^[3]。笔者回顾性分析了 2009 年 10 月至 2012 年 5 月经穿刺或手术病理证实为乳腺癌 42 例患者的临床资料,旨在评价全数字 X 线摄影联合动态增强 MR 检查在早期乳腺癌诊断中的价值。

1 资料与方法

1.1 一般资料

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共收集 2009 年 10 月至 2012 年 5 月经穿刺或手术病理确诊为乳腺癌的患者 42 例(共 42 个病灶),病灶组织学或临床分期均为早期,病灶直径 0.8~2.0 cm,平均 1.3 cm,无淋巴结转移。患者均为女性,年龄 35~75 岁,术前均于我院行数字 X 线及动态增强 MR 检查。其中浸润性导管癌 32 例,导管原位癌 8 例,早期小叶浸润癌 1 例,粘液癌 1 例。

1.2 检查方法

1.2.1 全数字化乳腺 X 线摄影检查 采用美国 GE 公司生产的 Senography DS 全数字化平板乳腺 X 线摄影机,常规采用头尾位(CC)和内外斜位(MLO)进行双乳摄影,乳腺压迫板压力为 10-12 daN,应用自动参数选择(AOP)技术根据乳腺厚度、密度自动确定阳极靶面(钨或钼)、滤波片、kV 和 mAs。乳房加压厚度 30-50 mm。必要时局部点压放大摄影(spot compression and magnification)。

使用医生工作站高分辨竖屏显示器(显示矩阵 2.5 K × 2.5 K)观察图像。

1.2.2 动态增强 MR 检查 采用 GE Signa Excite HD 3.0 T

MR 扫描仪和乳腺 8 通道表面相控阵线圈。被检者取俯卧位脚先进,双乳自然悬垂入线圈的孔洞内。扫描序列:平扫包括非脂肪抑制 FSE-XL T1WI 和常规 FSE-IR T2WI 横轴位、脂肪抑制 FSE-XL T2WI 矢状位平扫。增强采用 VIBRANT 技术行双侧乳腺三位薄层高分辨动态增强扫描,增强对比剂为钆喷酸葡胺(Gd-DTPA)或钆贝葡胺,剂量 0.1~0.2 mmol/kg 体重、注射速率 2 mL/s。扫描前手动寻找中心频率,注射对比剂前先扫描 Asset 校准和 mask 蒙片,患者保持原体位不变,注射对比剂的同时开始连续扫描 6 个 VIBRANT 增强时相。

扫描结束后将图像传至 ADW 4.3 工作站进行后处理和分析。应用 Functool 软件绘制时间-信号强度曲线。兴趣区(regions of interest, ROI)(最少包括 3 个体素)放置在病灶早期强化最明显处和对侧对称部位正常乳腺处,尽量避开大血管、病灶坏死部位。观察时间-信号强度曲线类型、早期强化率、增强后病灶形态学特征及间接征象。根据需要进行减影、MIP(最大强度投影)及 VR(容积)重建。

时间-信号强度曲线分为 3 型^[4]: I 型,持续型,病灶强化信号强度在延迟期随着时间的延长而继续增加,(2-3 min 后信号强度的升高超过 10%); II 型,即平台型,病灶早期强化后,在增强的中、后期信号强度维持在一个平台水平(信号强度的波动幅度在 <10%); III 型,即廓清型,早期强化后,在增强的中、后期信号强度降低(信号强度的降低超过 10%)。

1.3 影像评价

由两位主治以上影像诊断医师按照美国放射学会(The American College of Radiology, ACR)制订的乳腺影像报告及数据系统 (Breast Imaging Reporting and Data System, BI-RADS)^[5]中的描述术语对病灶进行分析、判断病灶的影像学特征,并进行分级。采用盲法读片。结果如有异议,则共同讨论确定。

1.4 统计学分析

应用 SPSS 13.0 统计软件,计数资料比较采用非参数 χ^2 检验, $P < 0.05$ 表示差异有统计学意义。

2 结果

2.1 全数字化 X 线摄影的结果

42 例患者中共发现病灶 38 个,29 个病灶诊断为恶性病变(BI-RADS 4~5),病理结果均为恶性,表现为边缘毛刺肿块 18 例、肿块内伴有钙化 8 例、单纯恶性钙化 3 例(图 1)。9 个病灶误诊为良性病变,表现为类圆形边缘较光滑肿块 3 例,局部不对称密度 6 例。漏诊 4 例,无明确阳性发现。准确率为 69.0% (29/42)。

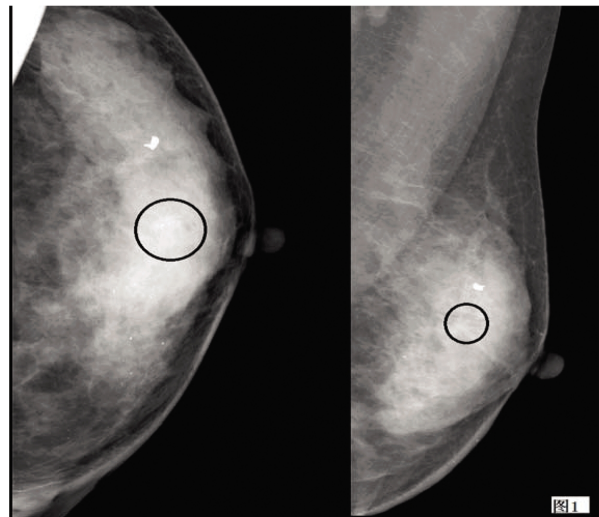


图 1 全数字化 X 线摄影图像示恶性微钙化。

左:头尾位;右:内外侧斜位

Fig.1 Mammography showed malignant calcification.

Left: CC. Right: MLO

2.2 动态增强 MR 检查的结果

共发现病灶 42 个,40 个初步诊断乳腺恶性肿瘤(BI-RADS 4~5),表现为不规则边缘毛刺肿块 26 例(III 型强化曲线 19 例, II 型强化曲线 7 例);边缘光滑类圆形、浅分叶肿块 7 例(II 型强化曲线 1 例,III 型强化曲线 6 例);局灶簇样强化 4 例(III 型强化曲线),节段样强化 3 例(III 型强化曲线)。2 个诊断为良性(BI-RADS 3),表现为边缘光滑类圆形均匀强化肿块(II 型强化曲线),准确率为 95.2%(40/42)。



图 2 (DCE-MRI)右乳外上象限肿块。时间-信号强度曲线 III 型:手术病理:浸润性导管癌

Fig.2 (DCE-MRI) a mass located in Right breast upper outer mass. TIC:III. Surgical Pathology: invasive ductal carcinoma

2.3 两种方法诊断早期乳腺癌的检出率比较

应用 χ^2 检验, X 线钼靶、MRI 增强检查诊断早期乳腺癌的

准确率分别为 69.0%和 95.2%, 两者比较差异具有统计学意义 ($P < 0.05$), 见表 1。而两种方法联合检查诊断早期乳腺癌与病

表 1 Mammo、DCE-MRI 诊断早期乳腺癌的准确率比较

Table 1 Comparison of the detection rate for early breast cancer between mammo and DCE-MRI

Mammo	DCE-MRI		合计
	+	-	
+	28	1	29
-	12	1	13
Total	40	2	42

理诊断的符合率为 97.6% (41/42)。

2.4 两种方法对各型(BI-RADS 分型)早期乳腺癌的诊断准确率比较

根据 BI-RADS 分型将病例分为 4 组,即致密型、多量腺体型、少量腺体型、脂肪型。两种方法对各型(BI-RADS 分型)早

期乳腺癌的诊断准确率比较结果见表 2。两种检查方法对致密型、多量腺体型乳腺的诊断准确率比较差异具有统计学意义($P<0.05$);而对少量腺体型和脂肪型乳腺的诊断准确率比较差异无统计学意义($P>0.05$)。

表 2 两种方法对各型(BI-RADS 分型)早期乳腺癌的诊断准确率比较

Table 2 Comparison of the diagnostic accuracy for various types of early breast cancer between mammo, and DCE-MRI

Type	(Mammo)		(DCE-MRI)	
	病灶个数 Number	准确率 Accuracy	病灶个数 Number	准确率 Accuracy
Dense (9)	4	44.4%▲	9	100%▲
Heterogeneous(17)	9	52.9%▲	16	94.1%▲
Fibrogranular(9)	9	100%●	8	88.8%●
Fatty(7)	7	100%●	7	100%●
Total	29	79.3%	40	95.2%

Note: ▲ $P<0.05$ Dense and Heterogeneous: Mammo Accuracy compared with DCE-MRI Accuracy; ● $P>0.05$ Fibrogranular and Fatty : Mammo Accuracy compared with DCE-MRI Accuracy.

3 讨论

3.1 Mammo 对早期乳腺癌的诊断价值

乳腺 X 线摄影是检查乳腺癌的首选影像学检查手段,可以从乳腺的整体来观察病灶情况,成像依赖于病变与正常乳腺间的密度差,其突出特点是对病灶的钙化具有良好的显示^[6]。本组 mammo 检出的 29 个乳腺癌病灶中,共显示钙化病灶 11 个(40.0%),肿块内伴有钙化 8 例,3 例仅表现为单纯恶性钙化灶,可见乳腺内恶性钙化是早期乳腺癌的一个重要甚至是唯一的 X 线征象。因此,Mammo 是检出早期乳腺癌,尤其是钙化型乳癌的首选手段^[7]。但是 Del Turco 等^[8]研究指出,在 Mammo 上,恶性病灶出现钙化的比率为 32%,较低的钙化出现比率导致了其诊断的困难性。乳腺癌的另一典型 X 线表现为边缘毛刺肿块,本组 mammo 检出的 29 个乳腺癌病灶中,边缘毛刺肿块 18 个(62.1%),但 X 线摄影的图像是重叠的二维图像,密度分辨率低,对致密型乳腺及多腺体型乳腺诊断敏感性差,肿块与增生腺体混在一起,分界不清,易发生误诊和漏诊。有研究认为致密型乳腺为患乳腺癌的高危因素,增加间期癌风险^[9]。与脂肪型乳腺相比,致密型乳腺患癌的风险增加了 2.2-5 倍^[10-11]。Ting. Kai 等^[12]认为亚洲女性腺体常较致密。本组研究中致密型乳腺占 62%,非致密型乳腺占 38%,与文献相符。本组致密型乳腺和多腺体乳腺病例中诊断准确率分别为 44.4%、52.9%,明显低于少腺体型和脂肪型。此外,mammo 仅能观察病变

形态特征,无法了解病变的血流动力学变化。

3.2 DCE-MRI 检查诊断早期乳腺癌的价值

MRI 具有软组织分辨率高、多方位和多参数成像的特点,对病变良恶性鉴别诊断价值高且无辐射损伤^[13]。越来越多的研究认为 MRI 对乳腺病变诊断的准确性高于 X 线和超声^[13-16],MRI 对病灶的检出,确定病灶范围、数量,观察病灶血流动力学变化及周边关系等方面具有明显优势。DCE-MRI 能清楚显示乳腺癌的形态特征和血流动力学特点。乳腺 MR 检查被认为是一种具有高敏感性和较高特异性的检查方式^[17-18]。有文献报道,其敏感度达到 85%~100%,而特异度为 40%~97%^[19]。本组病例中,对乳腺癌诊断的准确率达 95.2%(40/42),与文献相符。

DCE-MRI 检查的应用基础主要为乳腺癌新生的肿瘤血管、微血管密度增加;肿瘤血管对对比剂通透性增加和乳腺癌组织内细胞外间隙增大^[20]。乳腺癌的动态增强 MR 典型表现为边缘毛刺、不规则早期强化肿块。本组 26 例(61.9%)病灶符合此典型表现。此外,早期乳腺癌仅表现为局灶簇样、节段样强化灶,本组分别检出 4 例、3 例。典型乳腺癌时间-信号强度曲线为Ⅲ型(廓清型)强化曲线,有研究表明Ⅲ型时间-信号强度曲线的病变中 76%为恶性^[21]。本组显示 32 例(76.2%)病灶符合该曲线,与文献相符。DCE-MRI 检查的主要局限性是对微小钙化不敏感^[22],无法显示乳腺癌的恶性钙化。本组病例均未显示钙化。此外,乳腺癌的动态增强表现(包括时间-信号强度曲线)有部分与良性病变重叠。本组 10 例(23.8%)病灶表现为Ⅱ型(平

台型)强化曲线,其中2例误诊为良性病变。

3.3 DCE-MRI 与 Mammo 的联合应用诊断早期乳腺癌的价值

Mammo 具有准确性高、费用较低及操作简便等特点,对钙化敏感,可较好地鉴别钙化的良、恶性,但对于致密型乳腺中的小病灶、不典型的病变容易误诊及漏诊。据报道,单独使用钼靶 X 线对乳腺病变的敏感度仅为 25%~59 %^[23]。本研究根据 BI-RADS^[5]的分类标准将病例分为为四种类型,发现两种方法对少腺体型及脂肪型乳腺的早期乳腺癌诊断的准确率差异不大,但对于多腺体型及致密型乳腺有明显差异,动态增强 MR 检查诊断准确率明显高于 X 线摄影。

动态增强 MR 检查不受乳腺内腺体数量多少的影像,组织密度分辨率高,病灶形态结构显示清晰,并可通过测定病灶时间-信号强度曲线来鉴别病灶的良恶性,但对钙化的显示远远不如钼靶,而微小钙化在乳腺良恶性病变的鉴别诊断中占有重要地位,本组 DCE-MR 检查 2 例误诊病例在数字 X 线检查中其中 1 例表现为肿块内伴有微小钙化灶诊断为恶性,因此需结合 Mammo 进行诊断,评价 DCE-MR 图像时参考 mammo 所示病变部位/象限有无强化病灶分析动态增强特征来判断病变的性质。有文献报道,联合 MRI 对乳腺病变的敏感度则高达 93%~100 %^[24]。本组中两种检查方法联合应用,诊断准确率达 97.6 %,与文献报道相符。因此,二者联合应用对早期乳腺癌的检出有非常重要的临床意义。对于致密型及多腺体型乳腺的早期乳腺癌筛查中,动态增强 MR 检查可作为乳腺 X 线摄影的补充检查方法。

总之,本组研究结果显示动态增强 MR 检查对早期乳腺癌的诊断价值明显优于全数字 X 线摄影,但后者对微小钙化显示较好,两者联合可提高诊断正确率,尤其对多腺体型和致密型乳腺的早期乳腺癌的检出具有重要的价值。

参考文献(References)

- [1] Rebecca S, Elizabeth W, Otis B, et al. The impact of eliminating socioeconomic and racial disparities on premature cancer deaths[J]. CA Cancer J Clin, 2011, 61: 212
- [2] 胡永升. 现代乳腺影像诊断学[M]. 北京: 科学出版社, 2001: 45-75
Hu Yong-sheng. Modern breast imaging diagnostics [M]. Beijing: Science Press, 2001: 45-75
- [3] 刘明霞, 唐志全, 张艺军, 等. 3T 磁共振高分辨动态增强诊断小乳腺癌的应用研究[J]. 医学影像学杂志, 2011, 21(9): 1349-1351
Liu Ming-xia, Tang Zhi-quan, Zhang Yi-jun, et al. The value of high-resolution dynamic contrast-enhanced MRI in small breast cancer[J]. Journal of Medical Imaging, 2011, 21(9): 1349-1351
- [4] Kuhl C K, Schild H H. Dynamic image interpretation of the breast. JMR I, 2000, 11: 965-974
- [5] American College of Radiology (ACR). Breast imaging reporting and data system (BI-RADS) 4th ed, Reston: American College of Radiology, 2003, 1
- [6] 丁勇俊, 范晓芳, 王卫理, 等. 动态增强 MRI 联合钼靶 X 线对乳腺癌的诊断价值[J]. 苏州大学学报(医学版), 2009, 29(5)
Ding Yong-jun, Fan Xia-fang, Wang Wei-li, et al. Clinical evaluation of combining dynamic contrast-enhanced MRI and mammography for diagnosis of breast cancer [J]. Suzhou University Journal of Medical Science, 2009, 29(5)
- [7] 刘明霞, 张蕾, 刘琳, 等. 全数字化乳腺 X 线摄影诊断临床隐匿型乳腺癌的价值[J]. 现代生物医学进展, 2011, 11(21): 4156-4158
Liu Ming-xia, Zhang Lei, Liu Lin, et al. Full-field Digital Mammography Diagnosis of the Clinical Value of Occult Breast Cancer [J]. Progress in Modern Biomedicine, 2011, 11(21): 4156-4158
- [8] Del Turco MR, Mantellini P, Ciatto S, et al. Full-field digital versus screen-film mammography: comparative accuracy in concurrent screening cohorts[J]. Am J Roentgenol, 2007, 189: 860-866
- [9] Nothacker M, Duda V, Hahn M, et al. Early detection of breast cancer: benefits and risks of supplemental breast ultrasound in asymptomatic women with mammographically dense breast tissue. A systematic review[J]. BMC Cancer, 2009, 9: 335-343
- [10] Nagao Y, Kawaguchi Y, Sugiyama Y, et al. Relationship between mammographic density and the risk of breast cancer in Japanese women: a case-control study[J]. Breast Cancer, 2003, 10: 228-233
- [11] Ursin G, Ma H, Wu AH, et al. Mammographic density and breast cancer in three ethnic groups [J]. Cancer Epidemiol Biomarkers Prev, 2003, 12: 332-338
- [12] Leung Ting-kai, Huang Pal-jung, Lee Chi-Ming, et al. Can Breast Magnetic Resonance Imaging Demonstrate Characteristic Findings of Preoperative Ductal Carcinoma In Situ in Taiwanese Women? [J] Asian Journal of Surgery, 2010, 33: 143-149
- [13] 刘佩芳, 张淑平, 邵真真, 等. 磁共振成像对形态学表现为良性特征的乳腺恶性肿瘤诊断价值[J]. 磁共振成像, 2012, 3(2): 98-108
Liu Pei-fang, Zhang Shu-ping, Shao Zhen-zhen, et al. Breast MR imaging for distinguishing well-circumscribed breast malignancies from benign lesions[J]. Chin J Magn Reson Imaging, 2012, 3(2): 98-108(In Chinese)
- [14] Biglia N, Bounous VE, Martincich L, et al. Role of MRI (magnetic resonance imaging) versus conventional imaging for breast cancer presurgical staging in young women or with dense breast [J]. Eur J Surg Oncol, 2011, 37(3): 199-204
- [15] Gutierrez RL, DeMartini WB, Silbergeld JJ, et al. High cancer yield and positive predictive value: outcomes at a center routinely using preoperative breast MRI for staging [J]. AJR Am J Roentgenol, 2011, 196(1): 93-99
- [16] 刘佩芳, 鲍润贤. 乳腺 MRI 检查对乳腺癌个体化治疗的作用 [J]. 磁共振成像, 2011, 2(3): 182-189
Liu Pei-fang, Bao Run-xian. Breast MR imaging for the individual treatment of patient with breast cancer[J]. Chin J Magn Reson Imaging, 2011, 2(3): 182-189(In Chinese)
- [17] Berg WA, Gutierrez L, NussAiver MS, et al. Diagnostic accuracy of mammography, clinical examination, US, and MR imaging in preoperative assessment of breast cancer[J]. Radiology, 2004, 233: 830-849
- [18] Liberman L.B. Breast cancer screening with MRI-what are the data for patients at high risk[J]. N Engl J Med, 2004, 351: 497-500
- [19] Lord SJ, Lei W, Craft P, et al. A systematic review of the effectiveness of magnetic resonance imaging (MRI) as an addition to mammography and ultrasound in screening young women at high risk of breast cancer[J]. Eur J Cancer, 2007, 43(13): 1905-1917
- [20] 陈蓉, 龚水根, 张伟国, 等. 乳腺癌 MRI 形态学表现与病理、分子生物学相关性研究[J]. 中华放射学杂志, 2004, 38(6): 620-625

- Chen Rong, Gong Shui-gen, Zhang Wei-guo, et al. Correlativity study on MRI morphologic features, pathology, and molecular biology of breast cancer[J]. Radiology, 2004, 38(6): 620-625
- [21] Schnall MD, Blume J, Bluemke DA, et al. Diagnostic architectural and dynamic features at breast MR imaging: multicenter study [J]. Radiology, 2006, 238(1): 42-53(In Chinese)
- [22] 徐朝霞, 张学昕, 赵海涛, 等. 乳腺癌影像学检查对比研究[J]. 医疗卫生装备, 2010, 04: 361-363
- Xu Zhao-xia, Zhang Xue-xin, Zhao Hai-tao, et al. Comparatively Studying in Imaging Examination of Breast Cancer [J]. Chinese Medical Equipment Journal, 2010, 04: 361-363(In Chinese)
- [23] 刘治邦, 尉继伟, 张建萍, 等. X 线摄影对乳腺疾病钙化灶的诊断价值[J]. 中国医学影像技术杂志, 2008, 24
- Liu Zhi-bang, Wei Ji-wei, Zhang Jian-ping, et al. Diagnostic value of molybdenum target X-ray photography in calcification of breast disease[J]. Chinese Journal of Medical Imaging Technology, 2008, 24 (In Chinese)
- [24] Eubauer H, LI MX, Kuehne HR, et al. High grade and non-High grade ductal carcinoma in situ on dynamic MR mammography: characteristic findings for signal increase and morphological pattern of enhancement[J]. Br J Radiol, 2003, 76(901): 3-12

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- [4] Li S, Leshchynska I, Chernyshova Y, et al. The neural cell adhesion molecule (NCAM) associates with and signals through p21-activated kinase 1 (Pak1)[J]. J Neurosci, 2013, 33(2): 790-803
- [5] Garbian Y, Maori E, Kalev H, et al. Bidirectional transfer of RNAi between honey bee and Varroa destructor: Varroa gene silencing reduces Varroa population[J]. PLoS Pathog, 2012, 8(12): e1003035
- [6] Peer D. A daunting task: manipulating leukocyte function with RNAi [J]. Immunol Rev, 2013, 253(1): 185-197
- [7] Suzuki MG, Suzuki K, Aoki F, et al. Effect of RNAi-mediated knock-down of the Bombyx mori transformer-2 gene on the sex-specific splicing of Bmdsx pre-mRNA[J]. Int J Dev Biol, 2012, 56(9): 693-699
- [8] Blau JA, McManus MT. Renewable RNAi [J]. Nat Biotechnol, 2013, 31(4): 319-320
- [9] Cunha LC, Del Bel E, Pardo L, et al. RNA Interference with EAG1 Enhances Interferon Gamma Injury to Glioma Cells In Vitro [J]. Anticancer Res, 2013, 33(3): 865-870
- [10] 孙申, 高秀先, 朱圆圆. 钙粘附蛋白 N-cadherin 基因 RNAi 质粒载体的构建与鉴定[J]. 神经解剖学杂志, 2010, 26(2): 125-129
- Sun Shen, Gao Xiu-xian, Zhu Yuan-yuan, et al. Construction and identification of plasmid vector of RNA interference of N-cadherin gene[J]. Chinese Journal of Neuroanatomy, 2010, 26(2): 125-129
- [11] Uryu O, Kamae Y, Tomioka K, et al. Long-term effect of systemic RNA interference on circadian clock genes in hemimetabolous insects [J]. J Insect Physiol, 2013, 59(4): 494-499
- [12] Rao DD, Wang Z, Senzer N, et al. RNA interference and personalized cancer therapy[J]. Discov Med, 2013, 15(81): 101-110
- [13] Drosopoulos K, Linardopoulos S. Integration of RNAi and small molecule screens to identify targets for drug development[J]. Methods Mol Biol, 2013, 986: 97-104
- [14] Ditlevsen DK, Povlsen GK, Berezin V, et al. NCAM-induced intracellular signaling revisited[J]. J Neurosci Res, 2008, 86(4): 727-743
- [15] Krushel LA, Tai MH, Cunningham BA, et al. Neural cell adhesion molecule (NCAM) domains and intracellular signaling pathways involved in the inhibition of astrocyte proliferation[J]. Proc Natl Acad Sci USA, 1998, 95(5): 2592-2596
- [16] Ronn LC, Berezin V, Bock E. The neural cell adhesion molecule in synaptic plasticity and ageing [J]. Int J Dev Neurosci, 2000, 18(2-3): 193-199
- [17] Crossin KL, Krushel LA. Cellular signaling by neural cell adhesion molecules of the immunoglobulin superfamily[J]. Dev Dyn, 2000, 218(2): 260-279
- [18] Klinz SG, Schachner M, Maness PF. L1 and NCAM antibodies trigger protein phosphatase activity in growth cone enriched membranes[J]. J Neurochem, 1995, 65(1): 84-95
- [19] Euteneuer S, Yang KH, Chavez E, et al. Glial cell line-derived neurotrophic factor (GDNF) induces neuriteogenesis in the cochlear spiral ganglion via neural cell adhesion molecule (NCAM)[J]. Mol Cell Neurosci, 2012, 54C: 30-43
- [20] Guo S, Kemphues K J, Par-I. A gene required for establishing polarity in elegans embryos, encodes a putative Ser/Thr kinase that is asymmetrically distributed[J]. Cell, 1995, (4): 611-620