

能谱CT鉴别肺部炎性病变和肺癌的临床价值

王警建, 李娜, 王龙龙, 高延忠
西安市第九医院CT-MR室, 陕西 西安 710054

【摘要】目的:观察能谱CT对肺部炎性病变和肺癌的鉴别价值。**方法:**选取85例肺部占位病变患者,均采取能谱CT平扫、肺动脉期和主动脉期能谱扫描。根据病理结果将患者分为肺癌组与炎性病变组,比较两组IC_{肺动脉期}、IC_{主动脉期}、dIC_{肺动脉期}、dIC_{主动脉期}、dCT_{肺动脉期}、dCT_{主动脉期}、有效原子序数,并做受试者工作特性曲线判断不同参数的诊断效能。**结果:**85例患者中肺癌患者52例,炎性病变患者33例。肺癌患者的IC_{肺动脉期}、IC_{主动脉期}、dIC_{肺动脉期}、dIC_{主动脉期}、dCT_{肺动脉期}显著低于炎性病变患者($P<0.05$)。肺炎患者与炎性病变患者的dCT_{主动脉期}与有效原子序数无统计学意义($P>0.05$)。dIC_{肺动脉期}对肺癌与炎性病变的鉴别价值最大,敏感度高达0.966,同时标准误差仅0.027。**结论:**能谱CT的IC值与CT值有利于炎性病灶与肺癌的鉴别,其中dIC_{肺动脉期}的鉴别价值最大。

【关键词】能谱CT;肺癌;肺部炎性病变;鉴别;诊断;碘浓度

【中图分类号】R445.3

【文献标志码】A

【文章编号】1005-202X(2018)10-1164-05

Clinical value of energy spectrum CT for the differential diagnosis of pulmonary inflammatory lesion and lung cancer

WANG Jingjian, LI Na, WANG Longlong, GAO Yanzhong
CT-MR Room, Ninth Hospital of Xi'an, Xi'an 710054, China

Abstract: Objective To evaluate the value of energy spectrum computed tomography (CT) in differentially diagnosing lung inflammatory lesion and lung cancer. **Methods** A total of 85 patients with pulmonary space-occupying lesions were selected. All patients underwent energy spectrum CT plain scans, pulmonary artery and aortic scans. According to the pathological results, the patients were divided into lung cancer group and inflammatory lesion group. The iodine concentration (IC) of pulmonary arterial phase, IC of aortic phase, net increase of IC (dIC) of pulmonary artery phase, dIC of aortic phase, net increase of CT value (dCT) of pulmonary artery phase, dCT of aortic phase, and effective atomic number were compared between two groups. The diagnostic performance of different parameters was determined by receiver operating characteristic curve. **Results** Of the 85 patients, 52 patients were diagnosed with lung cancer and 33 were diagnosed with inflammatory lesions. IC of pulmonary arterial phase, IC of aortic phase, dIC of pulmonary artery phase, dIC of aortic phase, and dCT of pulmonary artery phase were significantly lower in patients with lung cancer as compared with those with inflammatory lesions ($P<0.05$). No statistical significance was found in dCT of aortic phase and effective atomic number between patients with pneumonia and those with inflammatory lesions ($P>0.05$). The dIC of pulmonary arterial phase had the greatest value in distinguishing lung cancer from inflammatory lesions, with a sensitivity of 0.966 and a standard error of only 0.027. **Conclusion** The IC value and CT value of energy spectrum CT are helpful for the differential diagnosis of inflammatory lesion and lung cancer, among which the dIC of pulmonary arterial phase has the greatest discriminative value.

Keywords: energy spectrum CT; lung cancer; pulmonary inflammatory lesion; differential diagnosis; iodine concentration

前言

肺癌和炎性病灶均为常见肺部病变,二者治疗

方法与预后存在较大差异。炎性疾病以抗感染治疗为主,肺癌患者往往需行手术及放化疗。以往临床多采用常规CT检查肺部病变,判断病灶良恶性。炎性结节或肿块与肺癌的征象存在较大差异,比较好鉴别^[1]。但当肺癌较大时,反而会出现类圆形、边缘光滑等良性病变征象,加之二者均存在明显强化,而对于肺癌和炎性病灶的鉴别,常规CT检查的应用有

【收稿日期】2018-04-24

【作者简介】王警建,副主任医师, E-mail: gg29018327@qq.com

【通信作者】高延忠,主治医师, E-mail: 308074959@qq.com

限^[2]。宝石能谱CT为新型CT设备,可在0.5 ms内实现高能级和低能级的快速切换交替扫描,获得高质量能谱图像,并测量碘基值,通过定量分析鉴别肺部病变的良恶性^[3]。本研究回顾性分析85例行能谱增强扫描的肺部占位病变患者的临床资料,探讨能谱CT对肺部炎性病变和肺癌的鉴别价值,以期为临床提供参考。

1 资料与方法

1.1 纳入与排除标准

纳入标准:(1)因肺部占位病变行能谱CT检查患者,病变均经手术、支气管镜或肺穿活检病理证实;(2)肺内占位直径>8 mm;(3)扫描图像质量满意;(4)临床资料完善。排除标准:(1)伴甲状腺功能异常、重症肌无力者;(2)伴严重心、肝、肾功能障碍者;(3)合并糖尿病或有双胍类药物应用史者;(4)对比剂过敏者;(5)有胸部放疗史者;(6)肺癌患者检查前接受过临床抗肿瘤治疗者;(7)妊娠与哺乳期女性;(8)合并其他恶性疾病者。

1.2 临床资料

选取85例符合以上纳入标准与排除标准的患者的临床资料进行回顾性分析,病例采集时间2016年3月~2018年3月,其中男48例、女37例;年龄46~74岁,平均(62.85±7.69)岁。

1.3 方法

1.3.1 仪器扫描方法 扫描仪器为GE Discovery 750HD CT。检查前空腹8 h左右,扫描前15 min左右饮水少量。扫描前由医生指导进行深吸气后屏气训练。仰卧位,足先进,双臂上举。扫描范围:肺尖至肺底膈面。行平扫联合能谱模式扫描(包括肺动脉期与主动脉期)。扫描条件:管电流375 mA,管电压80 kVp与140 kVp瞬时切换,螺距0.984,球管旋转时间0.7 s,扫描视野500 mm,准直器40 mm,层厚、层距均5 mm。平扫后高压注射(速率3 mL/s)非离子型碘造影剂(碘佛醇,江苏恒瑞医药股份有限公司生

产,规格:320 mg/mL),注射剂量1.0 mL/kg。注射后8~16 s及25~32 s采用追踪法行能谱扫描(肺动脉期与主动脉期分别进行)。对平扫、能谱扫描图像进行薄层重建,能谱成像自适应统计迭代重建40%,层厚与层距均1.25 mm。

1.3.2 图像后处理 将所得图像传至ADW 4.6工作站,于70 keV薄层能谱图像上测量平扫、能谱扫描的CT值、(IC)值。感兴趣区放置在病变密度均匀层面,避开空洞、钙化区域及血管。平扫、能谱扫描图像的感兴趣区通过复制粘贴以确保相同。所有数据测量均在连续3个感兴趣区层面上,取平均值。测定IC,计算净增碘浓度值(dIC): $dIC_{\text{肺动脉期}} = IC_{\text{肺动脉期}} - IC_{\text{平扫}}$; $dIC_{\text{主动脉期}} = IC_{\text{主动脉期}} - IC_{\text{平扫}}$;计算净增CT值(dCT): $dCT_{\text{肺动脉期}} = CT_{\text{肺动脉期}} - CT_{\text{平扫}}$; $dCT_{\text{主动脉期}} = CT_{\text{主动脉期}} - CT_{\text{平扫}}$ 。

1.4 统计学处理

采用SPSS 19.0统计学软件处理数据,计量资料采用均数±标准差表示,比较采取独立样本 t 检验;生成受试者工作特性(Receiver Operating Characteristic, ROC)曲线,分析各参数诊断效能。以 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 病理结果

85例患者中,经术后病理、经肺穿活检、经支气管镜分别确诊41例、26例、18例。最终诊断结果:肺癌患者52例(腺癌29例、鳞癌23例),炎性病变患者33例。

2.2 碘浓度与净增碘浓度

肺癌患者的 $IC_{\text{肺动脉期}}$ 、 $IC_{\text{主动脉期}}$ 、 $dIC_{\text{肺动脉期}}$ 、 $dIC_{\text{主动脉期}}$ 均显著低于炎性病变患者($P<0.05$)。详见表1。

2.3 dCT与有效原子序数

肺癌患者的 $dCT_{\text{肺动脉期}}$ 显著低于炎性病变患者($P<0.05$),肺炎患者与炎性病变患者的 $dCT_{\text{主动脉期}}$ 与有效原子序数无统计学意义($P>0.05$),见表2。

表1 肺癌患者与炎性病变患者碘浓度与净增碘浓度的比较($\bar{x} \pm s$, 100 $\mu\text{g/mL}$)

Tab.1 Comparison of IC and dIC in patients with lung cancer and those with inflammatory lesion ($Mean \pm SD$, 100 $\mu\text{g/mL}$)

Patient	<i>n</i>	IC of pulmonary artery phase	IC of aortic phase	dIC of pulmonary artery phase	dIC of aortic phase
Lung cancer	52	6.51±3.20	15.79±4.25	4.41±2.48	12.52±4.38
Inflammatory lesion	33	12.01±4.31	22.78±5.60	9.68±3.74	20.74±6.39
<i>t</i> value	-	6.737	6.522	7.818	7.039
<i>P</i> value	-	<0.05	<0.05	<0.05	<0.05

IC: Iodine concentration; dIC: Net increase of IC

表2 肺癌患者与炎性病变患者净增CT与有效原子序数的比较($\bar{x} \pm s$)

Tab.2 Comparison of dCT and effective atomic number in patients with lung cancer and those with inflammatory lesion (Mean±SD)

Patient	n	dCT of pulmonary artery phase/HU	dCT of aortic phase/HU	Effective atomic number
Lung cancer	52	6.21±3.57	29.82±11.65	30.01±10.58
Inflammatory lesion	33	11.66±3.92	35.01±12.94	34.62±11.03
t value	-	6.602	1.917	1.926
P value	-	<0.05	0.059	0.058

dCT: Net increase of CT value

2.4 能谱CT的ROC曲线图

将能谱CT参数作为自变量、以病理结果作为因变量绘制ROC曲线,结果显示dIC_{肺动脉期}对肺癌与炎

性病变的鉴别价值最大,敏感度高达0.966,同时标准误差仅0.27。详见图1与表3。

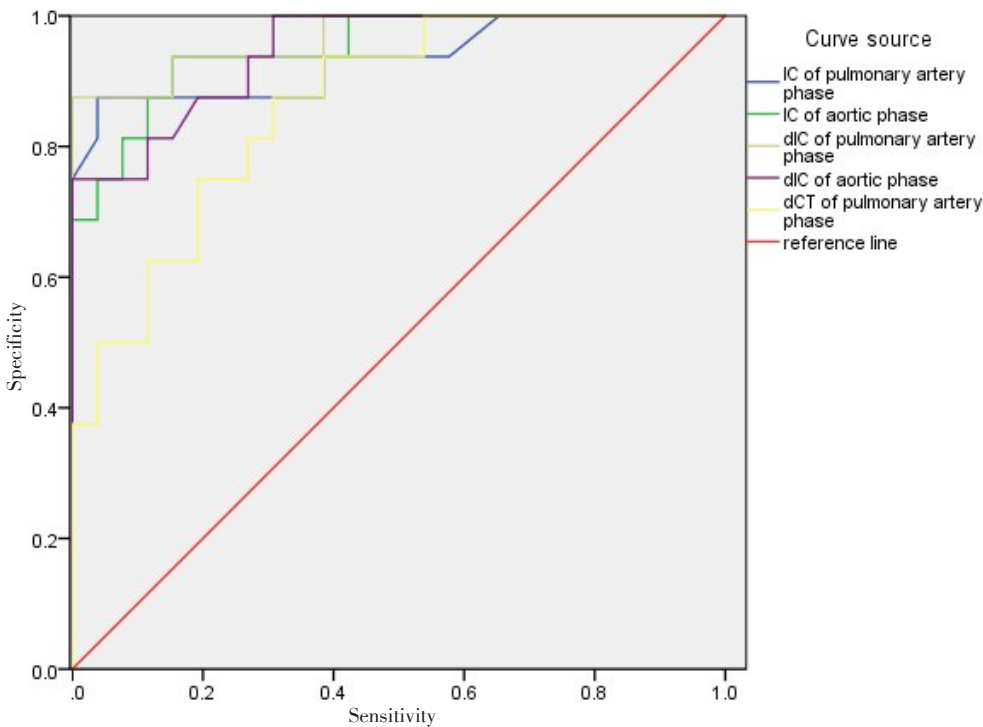


图1 能谱CT不同参数鉴别肺癌与炎性病变的ROC曲线图

Fig.1 Receiver operating characteristic (ROC) curves of different parameters of energy spectrum CT for the differential diagnosis of lung cancer and inflammatory lesion

表3 能谱CT不同参数绘制的ROC曲线的参数

Tab.3 Parameters of ROC curve drawn by different parameters of energy spectrum CT

Variable	Area	Standard error	Progressive Sig.	95% confidence interval	
				Lower	Limit
IC of pulmonary artery phase	0.934	0.045	0.000	0.846	1.000
IC of aortic phase	0.950	0.032	0.000	0.886	1.000
dIC of pulmonary artery phase	0.966	0.027	0.000	0.913	1.000
dIC of aortic phase	0.946	0.032	0.000	0.883	1.000
dCT of pulmonary artery phase	0.863	0.055	0.000	0.755	0.971

3 讨论

能谱CT可通过单源80 kVp与140 kVp之间的瞬时切换使常规CT的单参数成像变为多参数成像,且能量分辨率和化学分辨率均更高,图像更清晰^[4]。目前,能谱CT的研究内容已覆盖了全身各系统疾病的病灶检出、早期诊断、鉴别诊断,为临床医生提供了新的视角^[5-6]。临床已有较多有关CT灌注成像、双源CT成像诊断肺部病变的研究,但存在辐射剂量大、扫描野局限等不足^[7]。CT图像可体现物质对X线的吸收情况,并通过CT值进行反映。一般情况下物质对高能X线吸收相对较少而低能量相对较多^[8]。混合能量的X线通过物体后被硬化造成平均效应,引起CT值不准确。常规CT仅依靠CT值进行分析,而CT值不稳定,易受多种因素影响,如病灶中空气等^[9-10]。CT能谱图像则是以碘基图为基础物质,对碘对比剂具有较高的敏感性,利于对组织血供做出准确评估^[11]。能谱CT结合物质对X线的吸收规律,对基物质进行配比,再利用碘浓度反映病变强化程度,且碘浓度可相对准确地反映对比剂进入病灶的情况,并克服病灶中空气的影响,明确病灶血供情况,从而为炎性病变与肺癌的鉴别提供依据,这是CT能谱成像独特的多维度、定量分析优势^[12-13]。已有研究发现,碘基图可准确测定不同浓度碘溶液碘含量,准确性及可信度较高^[14]。

本研究中85例肺部病变患者均进行了能谱CT增强扫描,结果显示肺癌患者与炎性病变患者肺动脉期与主动脉期的碘浓度与净增碘浓度均存在显著差异,具体表现为肺癌患者的IC_{肺动脉期}、IC_{主动脉期}、dIC_{肺动脉期}、dIC_{主动脉期}、dCT_{肺动脉期}低于炎性病变患者。这一结果表明,较之CT值,IC值可更准确地反映病灶血供特点。炎性病灶多由炎性肉芽组织增殖形成,主要由肺动脉和支气管动脉供血,坏死组织相对肺癌患者较少,血管结构相对较正常,故造影剂流通快,肺动脉期与主动脉期均呈高而均匀强化^[15-16]。肺癌具有血管依赖性,由支气管动脉供血,故炎性病变患者肺动脉期CT图像与平扫CT图像的差值较肺癌患者更大。肺癌患者肿瘤内部血管丰富、血管通透,可使造影剂在瘤内聚集,故肺动脉期与主动脉期的IC与dIC会相对低于炎性病变患者。以往能谱CT研究多用IC值评估病灶血供,而平扫IC并非为零且病灶的不同也会造成差异。增强图像的IC值无法反映平扫与增强扫描的相对情况,故对病灶血供的评估可能不够准确。本研究中计算的dIC值可排除平扫IC的干扰,与病灶血供之间的关系更为密切,故可获

得更高的敏感性与特异性,诊断效能更佳。ROC曲线也进一步证实,dIC_{肺动脉期}对肺癌与炎性病变的鉴别价值最大。有效原子序数主要用来分析能谱成像中病灶的无机物成分,结石、矽肺、钙化等均为无机物成分^[17]。有效原子序数可测量、分析病灶中结石、钙化情况,以此明确病变的无机物含量,有助于肺部病变的进一步鉴别。

综上所述,能谱CT的IC与CT值有利于炎性病灶与肺癌的鉴别,其中dIC_{肺动脉期}的鉴别价值最大。

【参考文献】

- [1] 管乃超,胡春洪.肺部肿块性病变的能谱CT诊断价值[J].中国中西医结合影像学杂志,2014,12(4):372-374.
GUAN N C, HU C H. Diagnosis value of energy spectrum CT for pulmonary mass lesions[J]. Chinese Imaging Journal of Integrated Traditional and Western Medicine, 2014, 12(4): 372-374.
- [2] 吕晓波,樊鹏飞,景斐华,等.能谱CT多参数定量值在肺部占位病变鉴别诊断中的应用[J].中国基层医药,2016,23(15):2358-2361.
LÜ X B, FAN P F, JING F H, et al. Analysis of the application effect with energy spectrum CT multi-parameter quantitative values in pulmonary occupying lesions [J]. Chinese Journal of Primary Medicine and Pharmacy, 2016, 23(15): 2358-2361.
- [3] 蒋娜,陈志民,方天舒,等.宝石能谱CT临床应用进展[J].中国老年学杂志,2016,36(24):6319-6320.
JIANG N, CHEN Z M, FANG T S, et al. Progress in clinical application of gemstone spectrum CT [J]. Chinese Journal of Gerontology, 2016, 36(24): 6319-6320.
- [4] 盖立平,刘爱连,孙美玉,等.能谱CT成像多个测量参数分析[J].中国医学物理学杂志,2015,32(3):317-321.
GAI L P, LIU A L, SUN M Y, et al. Multiple parameters in spectral CT imaging[J]. Chinese Journal of Medical Physics, 2015, 32(3): 317-321.
- [5] 李信友,魏森,胡志华,等.对比剂方案对能谱CT肺动脉成像图像质量的影响[J].重庆医学,2017,46(15):2080-2082.
LI X Y, WEI M, HU Z H, et al. A study on the influence of contrast agent protocol on gem spectrum CT pulmonary angiography quality[J]. Chongqing Medicine, 2017, 46(15): 2080-2082.
- [6] 王丽杰,马继文,王永丽,等.能谱CT鉴别诊断孤立性肺结节或肿块的价值[J].中国临床医学影像杂志,2017,28(4):245-249.
WANG L J, MA J W, WANG Y L, et al. Application of spectral CT in differential diagnosis of solitary pulmonary nodules or masses[J]. Journal of China Clinic Medical Imaging, 2017, 28(4): 245-249.
- [7] ALMUTAIRI A, SUN Z, AL SAFRAN Z, et al. Optimal scanning protocols for dual-energy CT angiography in peripheral arterial stents: an *in vitro* phantom study[J]. Int J Mol Sci, 2015, 16(5): 11531-11549.
- [8] MACHIDA H, FUKUI R, TANAKA I, et al. A method for selecting a protocol for routine body CT scan using gemstone spectral imaging with or without adaptive statistical iterative reconstruction: phantom experiments[J]. Jpn J Radiol, 2014, 32(4): 217-223.
- [9] 李知书,马兵,陈绍平,等.螺旋CT及能谱CT与PET-CT扫描诊断肺癌的临床价值比较[J].西部医学,2017,29(11):1532-1536.
LI Z S, MA B, CHEN S P, et al. Diagnostic value of spiral CT, spectral CT and PET-CT scanning in patients with lung cancer[J]. Medical Journal of West China, 2017, 29(11): 1532-1536.
- [10] 李琦,罗天友,吕发金,等.能谱CT定量分析在确定非小细胞肺癌病理类型中的价值[J].中华放射学杂志,2017,51(4):257-261.
LI Q, LUO T Y, LÜ F J, et al. The value of quantitative analysis with spectral CT imaging in the diagnosis of non-small cell lung cancer

- with different pathological types[J]. Chinese Journal of Radiology, 2017, 51(4): 257-261.
- [11] 刘磊, 张毅, 支修益, 等. 宝石能谱CT在肺癌射频消融术中的应用[J]. 中华胸心血管外科杂志, 2015, 31(8): 490-493.
- LIU L, ZHANG Y, ZHI X Y, et al. The study on treatment efficacy using gemstone spectral CT in patients with lung cancer after radiofrequency ablation [J]. Chinese Journal of Thoracic and Cardiovascular Surgery, 2015, 31(8): 490-493.
- [12] 杨峰峰, 董杰, 闫晓龙, 等. 能谱CT定量参数:术前诊断肺癌转移性淋巴结的价值[J]. 中国肺癌杂志, 2016, 19(11): 738-745.
- YANG F F, DONG J, YAN X L, et al. GSI quantitative parameters: preoperative diagnosis of metastasis lymph nodes in lung cancer[J]. Chinese Journal of Lung Cancer, 2016, 19(11): 738-745.
- [13] 王宝玲, 周连新. 螺旋CT、能谱CT和MRI诊断原发性肝癌的临床价值比较[J]. 实用肝脏病杂志, 2016, 19(4): 467-470.
- WANG B L, ZHOU L X. Diagnostic value of spiral CT, CT and MRI spectroscopy in patients with primary liver cancer[J]. Journal of Practical Hepatology, 2016, 19(4): 467-470.
- [14] 赵云松, 张慧滔, 赵星, 等. 双能谱CT的迭代重建模型及重建方法[J]. 电子学报, 2014, 42(4): 666-671.
- ZHAO Y S, ZHANG H T, ZHAO X, et al. Iterative reconstruction model and reconstruction method for dual energy computed tomography[J]. Acta Electronica Sinica, 2014, 42(4): 666-671.
- [15] 胡志, 余晓镔, 康立丽, 等. 基于一种体模对CT能谱技术的质量检测[J]. 中国医学物理学杂志, 2018, 35(1): 54-59.
- HU Z, YU X E, KANG L L, et al. Phantom-based quality testing for spectral computed tomography technology[J]. Chinese Journal of Medical Physics, 2018, 35(1): 54-59.
- [16] 赵慧萍, 吕培杰, 张丽英, 等. 基于能谱CT智能匹配技术的半剂量能谱CT联合自适应统计迭代重建技术在肥胖患者上腹部扫描中的应用价值[J]. 中华医学杂志, 2017, 97(47): 3681-3686.
- ZHAO H P, LÜ P J, ZHANG L Y, et al. Application of half-dose spectral CT based on the automatic spectral imaging mode selection and adaptive statistical iterative reconstruction in the CT examination of upper abdomen in obese patients [J]. National Medical Journal of China, 2017, 97(47): 3681-3686.
- [17] ZHU Z, ZHAO X M, ZHAO Y F, et al. Feasibility study of using gemstone spectral imaging (GSI) and adaptive statistical iterative reconstruction (ASIR) for reducing radiation and iodine contrast dose in abdominal CT patients with high BMI values[J]. PLoS One, 2015, 10(6): 129-201.

(编辑:黄开颜)