Comparison of High-Resolution Computed Tomography with Pulmonary Function Testing in Symptomatic Smokers

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Abstract

Purpose: To compare high-resolution computed tomography (HRCT) of lungs with pulmonary function in smokers diagnosed with emphysema.

Material and Method: The authors retrospectively reviewed 17 patients with a history of smoking and dyspnea, who underwent HRCT of the lungs and pulmonary function testing. HRCT scores were determined and compared to pulmonary function (FEV1, FEV1/FVC, and DLCO).

Results: The HRCT of all 17 patients (17/17; 100%) were typical of centrilobular emphysema; with a mean score of 12.88±9.18 (range, 4 to 34). Decreased FEV1 (<80% predicted) was found in 8 patients (47%), decreased FEV1/FVC (<70% predicted) in 13 patients (76%) and decreased DLCO (<80% predicted) in 3 patients (18%). The severity of emphysema revealed by HRCT was inversely correlated with the pulmonary function test: DLCO (r=-0.842, p=0.000) and FEV1 (r=-0.597, p= 0.011), but not FEV1/FVC (r=-0.400, p=0.112).

Conclusion: HRCT allows detection of emphysema in symptomatic smokers even when pulmonary function appears to be normal. The greater the involvement of emphysema revealed by the HRCT, the poorer the pulmonary function. The authors, therefore, conclude that HRCT is the most sensitive modality for diagnosing early emphysema in smokers with dyspnea.

Key word : Emphysema, High-Resolution Computed Tomography, Pulmonary Function Test, Smoker

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Smokers with dyspnea are usually diagnosed by their clinical symptoms. The parameters, though these may not be detected until up to 30 per cent of lung involvement, are decreased airflow (measured by spirometry) and decreased carbon monoxide diffusing capacity (DLCO - due to parenchymal destruction)[1]. The diagnostic capability of the chest radiograph is best for moderate to severe emphysema[2]. High resolution CT (HRCT) has proven sufficiently sensitive for the diagnosis of even mild emphysema[3,4]. Centrilobular emphysema is commonly detected among smokers using HRCT, as the disease entity is easily identified by well-demarcated areas of low attenuation compared to the contiguous nature of a normal lung marginated by a very thin or indefinable wall[5-10]. The aim of the present study was to correlate HRCT and pulmonary function among symptomatic smokers.

MATERIAL AND METHOD

The authors retrospectively reviewed the hospital records of all 17 patients with a history of cigarette smoking and dyspnea, who underwent lung HRCT and pulmonary function testing (for FEV1, FEV1/FVC, DLCO) at Srinagarind Hospital between August 1996 and March 2000. The CT scanning was done at 20-mm intervals for the whole of both lungs, beginning at the level of the lung apex and proceeding caudally through the lung bases. All scans were performed using a HRCT technique with 1.5 mm collimation, 140 kVp, 170 mA, 2-second scanning, FOV 20 cm with small pixels 512x512 matrices, and a high-frequency reconstruction algorithm (bone algorithm). Images were photographed in a six-on-one format then displayed at window widths of 1,500 HU. Three levels of each HRCT study were viewed; at or just cephalic to the aortic arch, the tracheal carina, and the apex of the right hemidiaphragm, and were scored for overall severity by direct observation as per Sakai et al[7]. Each of the six lung sections evaluated from each patient was scored for the severity of emphysema (i.e. 0 = no emphysema, 1 = low attenuation areas <5 mm in diameter, 2 = circumscribed low attenuation areas >5 mm in diameter, 3 = diffuse low attenuation areas without intervening normal lung or large, confluent low attenuation areas). Then the extent of emphysema for each section was scored (i.e. 1 = <25% cross sectional area involvement, 2 = 25-50% involvement, 3 = 50-75% involvement, 4 = greater than 75% involvement). The product of the extent and severity for the six sections were summed, with a maximum possible score of 72 for each patient. Two radiologists, not apprised of the findings of pulmonary function, performed each examination by consensus.

The medical records were reviewed for the results of pulmonary function testing, which included spirometric measurement of forced expiratory

Table 1. Results of 17 patients with sex, age, HRCT (emphysema) scores and Pulmonary Function.

No.	Sex	Age Year	HRCT (Emphysema) scores	FEV1 (% Predicted)	FEV1/FVC (% Predicted)	DLCO (% Predicted)
1	M	70	15	47	44	89
2	M	55	6	101	60	122
3	M	62	8	78	74	118
4	M	44	7	84	63	130
5	M	57	6	87	66	110
6	M	42	17	83	74	98
7	M	56	10	93	64	87
8	M	71	10	60	43	98
9	M	48	8	90	71	111
10	M	71	5	83	54	149
11	M	59	24	84	80	79
12	F	73	12	34	29	95
13	M	59	4	77	65	138
14	M	68	9	53	48	117
15	M	61	33	34	35	72
16	M	43	11	95	65	87
17	M	60	34	35	32	55

volume in 1 second (FEV1) and the ratio of FEV1 to forced vital capacity (FVC), both expressed as "percentage predicted" with abnormal values being <80 and 70 per cent, respectively. Diffusing capacity was measured by assessing a single-breath for carbon monoxide diffusing capacity (DLCO). Abnormal flow rates indicating airflow obstruction and diminished diffusing capacity were <80 per cent predicted. The HRCT score was correlated to FEV1, FEV1/FVC and DLCO using Pearson correlation analyses.

Fig. 1. HRCT of the right lung demonstrates centrilobular emphysema (arrow heads).

RESULTS

Sex, age, HRCT score and pulmonary function for each patient are presented in Table 1. HRCT scans revealed centrilobular emphysema in all patients (16 men and 1 woman) with scores ranging between 4 and 34 (mean, 12.88±9.18) [Fig. 1]. Age averaged 59 years (range, 42 to 73). Abnormal pulmonary function tests occurred for: FEV1 (<80% predicted) in 8 (47.05%), FEV1/FVC (<70% predicted) in 13 (76.47%), and DLCO abnormality (<80% predicted) in 3 (17.65%) of the 17 patients, respectively. The mean FEV1 (±standard deviation) was 71.6%±22.8 predicted (range, 34 to 101% predicted), the mean FEV1/FVC was 56.88%±15.72 predicted (range, 29 to 80%), and mean DLCO was 103.2%±24.5 predicted (range, 55 to 149% predicted). HRCT scores were inversely correlated with DLCO (r=-0.842, p=0.000)[Fig. 2], and with FEV1 (r=-0.597, p=0.011)[Fig. 3], but not at all with FEV1/FVC; r=-0.400, p=0.112 [Fig. 4].

DISCUSSION

The diagnosis of the emphysema is based on clinical, functional and radiographic criteria. Emphysema causes expiratory airflow obstruction and decreased DLCO. Airflow obstruction, as com-

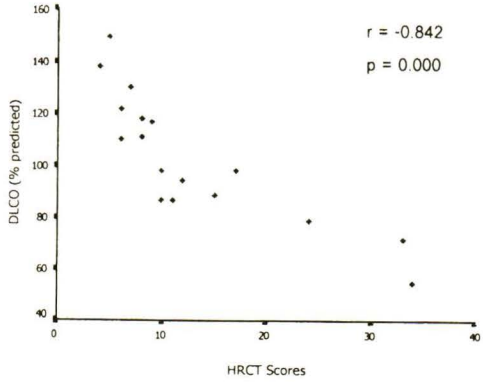

Fig. 2. Relationship between emphysema scores (HRCT) and DLCO.

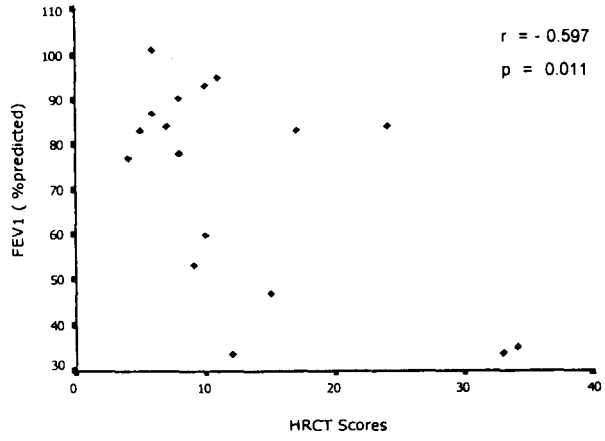

Fig. 3. Relationship between emphysema scores (HRCT) and FEV1.

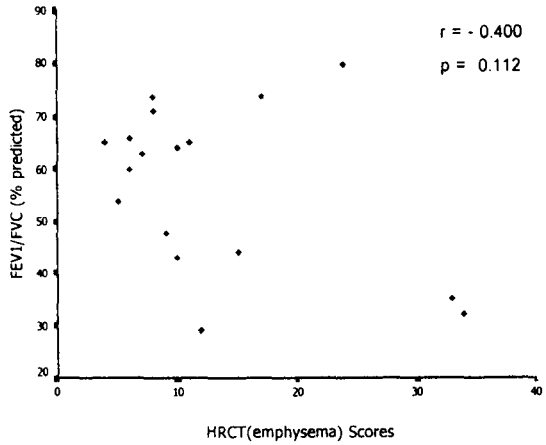

Fig. 4. Relationship between emphysema scores (HRCT) and FEV1/FVC.

monly measured by spirometry and presented as FEV1 and FEV1/FVC is secondary to increased airway resistance and decreased elastic recoil[2]; however, airway obstruction is not necessarily present in patients with mild emphysema, so normal pulmonary function should not be assumed[11]. Measurement of DLCO with a single breath-hold technique (SB) allows assessment of the integrity and surface area of the alveolar-capillary membrane within the lung[12]. If emphysema is present, decreased DLCO SB correlates with the severity of emphysema as found during post-mortem examinations[13], though some patients with mild to moderate morphologic emphysema may have a normal DLCO SB[14]. Not only is the DLCO SB normal in some patients with proven emphysema, but an abnormal DLCO SB can indicate a variety of pulmonary disorders affecting the alveolar-capillary interface, including interstitial lung disease and pulmonary vascular disease, such as pulmonary embolism and cystic fibrosis[15,16].

The radiographic diagnosis of emphysema is usually accurate in moderate to severe emphysema, so smokers with or without dyspnea with mild to moderate emphysema may be missed[17,18]. Recently, however, shorter scanning times, improved detector capabilities, and the ability to obtain thinly collimated sections and to reconstruct them with a high-spatial-resolution algorithm (HRCT), have allowed the depiction of mild centrilobular emphysema as well-defined areas of abnormally decreased attenuation lacking definable walls, situated within the secondary pulmonary lobule[5-10]. Several studies have shown a significant inverse correlation between the HRCT-determined severity of emphysema and functional markers of emphysema; such as airflow obstruction (FEV1, FVC and FEV1/FVC) and DLCO[16,19-21].

In the present review of 17 smokers with dyspnea, the authors found 8 (47.05%) with airflow obstruction by decreased FEV1 (<80% predicted), 13 (76.47%) by decreased FEV1/FVC (<70% predicted), and 3 (17.65%) by decreased DLCO. Emphysematous changes were apparent on the HRCT imaging on all of the patients. A strong correlation was found between HRCT scores with DLCO, and FEV1 (r=-0.842[p=0.000] and r=-0.597[p =0.011]), respectively. The patient with the highest HRCT score (#17 Table 1) also had the lowest DLCO and FEV1/FVC and nearly the lowest of FEV1.

SUMMARY

HRCT was more sensitive for diagnosing emphysema than pulmonary function testing in a significant subgroup of symptomatic patients. Further diagnostic evaluation was usually unnecessary. HRCT may now be the most sensitive and appropriate method available for detecting emphysema, even in patients with demonstrating normal pulmonary function.

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การเปรียบเทียบผลการตรวจของ High-Resolution Computed Tomography กับผลการตรวจสมรรถภาพของปอดในคนสูบบุหรี่ที่มีอาการ

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วัตถุประสงค์ : ต้องการเปรียบเทียบผลการตรวจระหว่าง High-resolution computed tomography (HRCT) ของปอดในคนสูบบุหรี่ที่ได้รับการวินิจฉัยว่าเป็นโรคถุงลมโป่งพองกับผลการตรวจสมรรถภาพของปอดชนิด spirometry (FEV, FEV/FVC), ความสามารถในการซึมผ่านของก๊าซคาร์บอนมอนอกไซด์ (DLCO)

วัสดุและวิธีการ : ผู้ป่วยที่มีประวัติสูบบุหรี่ที่มีอาการหอบเหนื่อย และได้รับการตรวจทั้ง HRCT และการทำงานของปอดในเวลาใกล้เคียงกัน จำนวน 17 คน ได้นำมาศึกษาเปรียบเทียบระหว่าง HRCT scores กับ FEV1, FEV1/FEC และ DLCO

ผลการศึกษา : ผู้ป่วยทั้ง 17 คน พบ emphysema โดย HRCT (คิดเป็น 100%) โดยมีค่าเฉลี่ยของ HRCT ที่ 12.88±9.18 (จาก 4-34) และทุกรายเป็น centrilobular emphysema พบผู้ป่วย 8 คน (8/17;47.05%) มีค่า FEV1 น้อยกว่า 80% predicted และผู้ป่วย 13 คน (13/17;76.47%) มีค่า FEV1/FVC น้อยกว่า 70% predicted และพบผู้ป่วยเพียง 3 คน (3/17;17.64%) มีค่า DLCO<80% predicted ความรุนแรงของโรคถุงลมโป่งพองที่พบโดย HRCT มีความสัมพันธ์ผกผันอย่างมีนัยสำคัญทางสถิติกับผลการตรวจสมรรถภาพปอดชนิด DLCO (r=0.842, p=0.000) และ FEV1 (r=-0.597, p=0.011) ตามลำดับ ยกเว้น FEV1/FVC (r=-0.400, p=0.112)

บทสรุป : จากผลการทดลองนี้ช่วยบ่งชี้ว่า HRCT สามารถตรวจพบโรคถุงลมโป่งพองในผู้ป่วยสูบบุหรี่โดยที่การตรวจสมรรถภาพของปอดยังเป็นปกติ ยิ่งตรวจพบปริมาณของถุงลมโป่งพองโดย HRCT มากเท่าไร การทำงานของปอดจะแย่ลงตามด้วย ผู้วิจัยจึงสามารถสรุปได้ว่า HRCT เป็นเครื่องมือที่ไวที่สุดในการตรวจภาวะถุงลมโป่งพองในกลุ่มคนสูบบุหรี่และมีอาการหอบเหนื่อย

คำสำคัญ : โรคถุงลมโป่ง, High-Resolution Computed Tomography, การทดสอบหน้าที่ปอด, ผู้สูบบุหรี่

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