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# 慢性阻塞性肺疾病患者超声监测膈肌增厚率与肺功能的相关性 *

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**摘要 目的：**探讨慢性阻塞性肺疾病(Chronic obstructive pulmonary disease，COPD)患者超声监测膈肌增厚率与肺功能的相关性。**方法：**2019 年 1 月到 2020 年 12 月选择在本院诊治的 COPD 患者 72 例作为 COPD 组，同期选择在本院体检的健康人 72 例作为对照组。采用超声监测两组入选者的膈肌增厚率，使用肺功能测定仪测定呼气流量峰值(peak expiratory flow，PEF)、第 1 秒用力呼气容积占预计值百分比(Forced Expiratory Volume in the first second，$FEV_1$)、肺活量 25 %时用力呼气流速(Vmax25%，V25)、肺活量 50 %时用力呼气流速(Vmax50%，V50)、肺活量 75 %时用力呼气流速(Vmax75%，V75)等指标并进行相关性分析。**结果：**COPD 组的膈肌增厚率低于对照组，对比差异有统计学意义($P$<0.05)。COPD 组的 $FEV_1$、PEF、V25、V50、V75 值都低于对照组，对比差异都有统计学意义 ($P$<0.05)。在 COPD 组患者中，Pearson 相关分析显示膈肌增厚率与 $FEV_1$、PEF、V25、V50、V75 都存在正相关性($P$<0.05)。Logistic 回归分析显示 $FEV_1$、PEF、V25、V50、V75 为影响膈肌增厚率的重要影响因素 $P$<0.05)。**结论：**COPD 患者超声监测可显示膈肌增厚率与肺功能降低，两者存在相关性，肺功能下降也是导致患者膈肌增厚率降低的重要危险因素。

**关键词：**慢性阻塞性肺疾病；膈肌增厚率；肺功能；超声监测；呼气流量峰值；相关性；危险因素

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# The Correlation between the Diaphragm Thickening Rate and Lung Function in Patients with Chronic Obstructive Pulmonary Disease*

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**ABSTRACT Objective:** To investigate the correlation between ultrasound monitoring of diaphragm thickening rate and lung function in patients with chronic obstructive pulmonary disease (COPD). **Methods:** From January 2019 to December 2020, 72 cases of patients with COPD who were diagnosed and treated in this hospital were selected as the COPD group, and the other 72 cases healthy people who given physical examination in this hospital during the same period were selected as the control group. Ultrasound were used to monitor the diaphragm thickening rate of the two groups, and the pulmonary function tester were used to measure the peak expiratory flow (PEF), Forced Expiratory Volume in the first second ($FEV_1$), Vmax25 %(V25), Vmax50 %(V50),Vmax75 %(V75), et al. and were given correlation analysis. **Results:** The thickening rate of diaphragm in the COPD group were lower than that in the control group ($P$<0.05). The $FEV_1$, PEF, V25, V50, and V75 values of the COPD group were lower than those of the control group that compared the difference were statistically significant ($P$<0.05). In the COPD group, Pearson correlation analysis showed that the rate of diaphragmatic muscle thickening were positively correlated with $FEV_1$, PEF, V25, V50, and V75 that compared the difference were statistically significant($P$<0.05). Logistic regression analysis showed that $FEV_1$, PEF, V25, V50, and V75 were important factors affected the thickening rate of the diaphragm ($P$<0.05). **Conclusion:** Ultrasound monitoring of COPD patients can show that the rate of diaphragmatic muscle thickening is correlated with the decrease of lung function. Decreased lung function are also important risk factors lead to the decrease of diaphragmatic muscle thickening rate.

**Key words:** Chronic obstructive pulmonary disease; Diaphragm thickening rate; Lung function; Ultrasound monitoring; Peak expiratory flow; Correlation; Risk factors

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## 前言

COPD 是呼吸系统常见和多发的慢性病，可严重影响患者的肺功能，导致患者的日常生活能力和生活质量严重下降[1]。随

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着气候、环境改变和吸烟人数的增加，COPD 发病率逐年升高[2,3]。该病可累及多个系统，具有高患病率、病死率等特点。COPD 在长期的发病过程中会导致患者发生膈肌形态学变化，使肺活动耐力下降，出现呼吸困难[4]。超声测量膈肌增厚率来评价膈肌功能，具有方便、无创、客观、快捷等优点，也可间接定量反映膈肌功能[5,6]。现代研究表明 COPD 以气道、肺实质等炎症反应为特征，伴随有肺功能的变化，严重情况下可重塑肺血管内膜，收缩肺血管，进行性升高跨肺压力梯度及肺血管阻力，最终发展为肺动脉高压[7-9]。本研究具体探讨了 COPD 患者超声监测膈肌增厚率与肺功能的相关性，希望能够找出判断 COPD 患者病情的指标，现总结报道如下。

## 1 资料与方法

### 1.1 研究对象

2019 年 1 月到 2020 年 12 月选择在本院诊治的 COPD 患者 72 例作为 COPD 组，同期选择体检的健康人 72 例作为对照组。纳入标准：年龄 30~75 岁；COPD 组符合 COPD 的诊断标准；无其他胸部、心血管系统、神经肌肉疾病等；本人及家属签署知情同意书；生命体征稳定；入选者能耐受并配合肺功能和超声检查。排除标准：神经肌肉疾病、胸廓畸形患者；合并恶性肿瘤、严重感染、急性心力衰竭患者；曾接受肺叶切除者的患者；患有糖尿病、淋巴瘤等恶性疾病和自身免疫缺陷疾病者；意识或精神障碍者；COVID-19 患者或康复者；妊娠期或哺乳期妇女；依从性差，预期不能完成本研究者。

两组入选者的吸烟、体重指数、性别、年龄、收缩压、舒张压等对比无差异($P$>0.05)，见表 1。

**表 1 两组一般资料对比**

Table 1 Comparison of two general data

| Groups | n | Gender (M/F) | Age (years) | BMI (kg/m$^2$) | Smoking | SBP(mmHg) | DBP(mmHg) |
|---|---|---|---|---|---|---|---|
| COPD group | 72 | 36/36 | 56.23± 1.20 | 22.89± 2.89 | 37(51.4) | 124.20± 18.22 | 71.44± 9.14 |
| Control group | 72 | 37/35 | 56.11± 2.19 | 22.39± 1.04 | 36(50.0) | 124.11± 19.42 | 71.99± 10.42 |

### 1.2 超声方法

采用 Supersonic 彩色多普勒超声诊断仪，配有凸阵探头，探头频率 3~5 MHz。患者取仰卧位，床头抬高 20°-40°，以肝脏或脾脏作为膈肌透声窗，于右肋缘下右腋前线与右锁骨中线的中点测量膈肌轨迹。嘱患者深呼吸 10~15 次，采集并储存呼吸过程中右侧膈肌厚度变化，测量吸气末及呼气末膈肌厚度。计算膈肌增厚率，膈肌增厚率 =(吸气末膈肌厚度 - 呼气末膈肌厚度)/ 呼气末膈肌厚度× 100 %，测量 3 个呼吸周期取平均值。

### 1.3 肺功能检查

采用德国 Jeager 公司生产的 Masterscreen－Diff 肺功能测定仪，测定相关肺功能指标，包括 PEF、$FEV_1$、V25、V50、V75等。

### 1.4 统计方法

选用 SPSS24.00，计量数据用 $\bar{x}\pm s$ 表示(对比为 t 检验)，计数数据用百分比表示(对比为 $x^2$ 检验)，对相关性分析采用 Pearson 相关分析与 Logistic 回归分析，$P$<0.05 有统计学意义。

## 2 结果

### 2.1 膈肌增厚率对比

COPD 组的膈肌增厚率为(19.47± 2.22)%，低于对照组的(28.33± 1.69)%(t=12.573，$P$<0.05)，见表 2。

**表 2 两组膈肌增厚率对比(%，$\bar{x}\pm s$)**

Table 2 Comparison of diaphragm thickening rate between the two groups (%, $\bar{x}\pm s$)

| Groups | n | Diaphragm thickening rate |
|---|---|---|
| COPD group | 72 | 19.47± 2.22* |
| Control group | 72 | 28.33± 1.69 |

Note: *Compared with control group, $P$<0.05.

### 2.2 肺功能指标对比

COPD 组的 $FEV_1$、PEF、V25、V50、V75 值 (60.13± 6.95%、61.85± 13.21%、55.65± 9.64%、53.01± 6.87%、51.23± 5.98%)都低于对照组 (80.31± 7.81%、88.01± 6.23%、69.32± 6.98%、70.98± 6.98%、78.98± 4.65%)，对比差异都有统计学意义($P$<0.05)，见表 3。

**表 3 两组肺功能指标对比(%，$\bar{x}\pm s$)**

Table 3 Comparison of lung function indexes between the two groups (%, $\bar{x}\pm s$)

| Groups | n | PEF | $FEV_1$ | V25 | V50 | V75 |
|---|---|---|---|---|---|---|
| COPD group | 72 | 60.13± 6.95* | 61.85± 13.21* | 55.65± 9.64* | 53.01± 6.87* | 51.23± 5.98* |
| Control group | 72 | 80.31± 7.81 | 88.01± 6.23 | 69.32± 6.98 | 70.98± 6.98 | 78.98± 4.65 |

Note: *Compared with control group, $P$<0.05.

### 2.3 相关性分析

在 COPD 组患者中，Pearson 相关分析显示膈肌增厚率与 $FEV_1$、PEF、V25、V50、V75 都存在正相关性($P$<0.05)，见表 4。

表 4 COPD 患者超声监测膈肌增厚率与肺功能的相关性(n=72)

Table 4 The correlation between the rate of diaphragmatic muscle thickening and lung function in patients with COPD (n=72)

| Index | $FEV_1$ | PEF | V25 | V50 | V75 |
|---|---|---|---|---|---|
| r | 0.444 | 0.644 | 0.513 | 0.413 | 0.452 |
| *P* | 0.009 | 0.000 | 0.005 | 0.011 | 0.008 |

### 2.4 影响因素分析

在 COPD 组患者中，以膈肌增厚率作为因变量，以 $FEV_1$、PEF、V25、V50、V75 作为自变量，Logistic 回归分析显示 $FEV_1$、PEF、V25、V50、V75 为影响膈肌增厚率的重要影响因素($P$<0.05)，见表 5。

表 5 影响 COPD 患者膈肌增厚率的多因素 Logistic 回归分析(n=72)

Table 5 Multivariate Logistic Regression Analysis of Diaphragm Thickening Rate in COPD Patients (n=72)

| Index | B | SE | Wald | *P* | OR | 95%CI |
|---|---|---|---|---|---|---|
| $FEV_1$ | 0.798 | 0.613 | 5.782 | 0.024 | 2.145 | 1.038-3.444 |
| PEF | 0.771 | 0.562 | 7.322 | 0.005 | 2.198 | 1.098-3.281 |
| V25 | 0.678 | 0.513 | 9.653 | 0.000 | 3.173 | 1.992-4.278 |
| V50 | 0.114 | 0.287 | 4.683 | 0.031 | 1.103 | 1.088-3.764 |
| V75 | 0.204 | 0.338 | 5.882 | 0.023 | 1.225 | 1.123-1.982 |

Note: Multi-factor Logistic regression analysis assignment: PEF≧70.22%=1, <70.22%=0; $FEV_1$≧75.22%=1, <75.22%=0; V25≧64.22%=1, <64.22%=0; $FEV_1$≧ 67.91%=1, <67.91%=0; $FEV_1$≧69.11%=1, <69.11%=0.

## 3 讨论

COPD 的发病与有毒颗粒或气体诱发气道或肺部慢性炎症密切相关。本研究显示 COPD 组的膈肌增厚率低于对照组，与 Kracht J[11]、Bordoni B[12]等学者的研究结果类似。从机制上分析，膈肌是人体最重要的呼吸肌，承担 70 %左右的通气支持功能。感染、机械通气、肺部疾病等因素均可影响人体的膈肌功能[13-15]。男性膈肌运动度的正常值为 4.7 cm，女性为 3.7 cm，男、女之间的膈肌移动度差异除了与结构差异有关外，还与女性肌肉力量弱、肺容量小等有关[16]。研究表明，平静呼吸时，人体膈肌厚度的正常值为 0.32 cm 左右[17]；用力呼吸时，人体膈肌厚度可增加到 0.55 cm 左右，可能与膈肌代偿性增加移动度来保证通气量有关[18]。而 COPD 患者膈肌存在长度短、位置低、肌肉力量减少、膈肌运动受限等特点，从而导致膈肌增厚率降低[19,20]。

COPD 是呼吸系统疾病中的常见病和多发病，也是目前全球致残和致死率较高的疾病之一[21]。气道、肺实质及肺血管的慢性炎症是 COPD 患者的特征性改变，巨噬细胞、T 淋巴细胞、中性粒细胞等多种炎症细胞均参与了 COPD 的发病过程[22,23]。本研究显示 COPD 组的 FEV1、PEF、V25、V50、V75 值都低于对照组，与 Nguyen T[22]、Ogan N[23]等学者的研究结果类似。从机制上分析，COPD 患者的气流受限可导致气道阻塞，从而使得机体的通气能力降低，也会导致患者出现呼吸驱动不足、二氧化碳潴留、通气能力下降等临床表现[24]。并且 COPD 的持续发病可损伤肺泡毛细血管屏障，可直接刺激管壁平滑肌细胞，使得内皮源性舒张因子和内皮源性收缩因子平衡失调，导致血管重塑，造成患者肺功能下降[25,26]。同时 COPD 患者的气道阻塞增加了呼吸肌的工作负荷，引起肺气肿，可导致膈肌偏移减少，从而进一步降低膈肌参与吸气的能力[27,28]。快速缓解临床症状、改善呼吸循环功能，避免导致重要器官功能衰竭是 COPD 成功治疗的关键。

COPD 患者在临床上以气促和呼吸困难为主要症状，其不仅仅是单纯的呼吸疾病，更是一种整体性疾病。当前临床上鉴别 COPD 的原因及需要及时评估患者膈肌的功能与状况，超声监测能实时显示组织器官的运动情况，且具有无辐射、操作简便等特点[29]。膈肌功能障碍是 COPD 患者常见的并发症，膈肌运动不仅是膈肌收缩舒张的结果，可能受到体位的影响[30]。特别是当人体腹部或胸部压力改变时，患者膈肌移动显著下降，但与膈肌本身的收缩功能无关，为此临床上当前比较少采用膈肌移动度评定患者的肺功能。本研究 Pearson 相关分析显示 COPD 患者的膈肌增厚率与 $FEV_1$、PEF、V25、V50、V75 存在正相关性；Logistic 回归分析显示 $FEV_1$、PEF、V25、V50、V75 为影响膈肌增厚率的重要影响因素，这也是本研究的创新之处，明确了 COPD 患者的膈肌增厚率与肺功能降低存在相关性，肺功能下降也是导致患者膈肌增厚率降低的重要危险因素。从机制上分析，COPD 患者可导致患者出现肺气肿与残气量增加，两者都增加了膈肌移动的阻力，导致膈肌增厚率减少[31]。

COPD 患者在身心上都承受着很大困难，因此在医院接受治疗期间很容易产生医患矛盾，也影响自身的生活质量[32,33]。特别是 COPD 还会使膈肌的脚部和肋部的力学方向改变为接近平行排列，肺过度充气会减少膈肌的长度，限制了肋间肌的吸气力学效能，可进一步降低膈肌参与吸气的能力，导致膈肌重塑，横膈膜变平，从而使膈肌增厚率减少[34,35]。本研究也存在一定的不足，没有 COPD 患者的病情进行分级处理，且观察的指标比较少，纳入患者的数量比较少，并且膈肌厚度都是测量膈肌上的单一位点，导致研究可能存在偏倚状况，将在后续研究中进行探讨。

总之，COPD 患者超声监测可显示膈肌增厚率与肺功能降低，两者存在相关性，肺功能下降也是导致患者膈肌增厚率降低的重要危险因素。

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