·综述·

超声评估膈肌功能及其临床应用进展

曹延祥,刘朝阳*

(中国人民解放军总医院第二医学中心综合外科,国家老年疾病临床研究中心,北京 100853)

【摘 要】 膈肌是最重要的呼吸肌,承担着约75%的呼吸做功。可通过超声测量膈肌厚度、膈肌移动度等指标来评估膈肌功能,进而辅助临床医师作出相应决策。膈肌超声在预测机械通气患者脱机结局、协助诊断慢性阻塞性肺疾病、预测全身麻醉术后肌松残余、预测术后肺部并发症及评估康复训练效果等方面有潜在价值。本文就膈肌的超声评估方法及临床应用情况进行综述,以期指导临床医师应用超声相关指标来评估膈肌功能,希望对临床工作提供帮助。

【关键词】 超声;膈肌功能;临床应用

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Progress in ultrasound assessment of diaphragm function and its clinical application

Cao Yanxiang, Liu Chaoyang*

(Department of General Surgery, Second Medical Center, National Clinical Research Center for Geriatric Diseases, Chinese PLA General Hospital, Beijing 100853, China)

【Abstract】 The diaphragm, the most important respiratory muscle, is responsible for about 75% of the work of breathing. Diaphragmatic function can be assessed by measuring its thickness excursion by ultrasound, thereby assisting clinicians in making corresponding decisions. Diaphragmatic ultrasound has potential value in predicting the outcome of weaning in patients with mechanical ventilation, assisting the diagnosis of chronic obstructive pulmonary disease, predicting residual muscle relaxation after general anesthesia, predicting postoperative pulmonary complications, and assessing the effect of rehabilitation training. This article reviewed the ultrasound assessment methods of the diaphragm and its clinical application, thus providing guide for the clinicians to assess diaphragm function using ultrasound-related indicators and helping clinical work.

【Key words】 ultrasound; diaphragm; clinical application

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Corresponding author: Liu Chaoyang, E-mail: midsunliu@aliyun.com

膈肌是一个由中央的肌腱结构和周围的骨骼肌结构组成的“穹顶样”的纤维肌性器官,位于胸、腹腔之间,是最主要的呼吸肌,其承担约75%的呼吸做功[1]。中枢神经系统疾病、机械通气、胸腹部手术及感染等多种因素均可影响膈肌功能。在临床上可通过X线片、电子计算机断层扫描(computed tomography,CT)、磁共振成像(magnetic resonance imaging,MRI)、跨膈压及肌电图等多种方法对膈肌功能进行评估。超声以其安全方便、简单无创、价格合理、可实现床旁实时动态观察等优势,近年来在膈肌功能评估方面广泛应用[2]。本文将就临床常用的膈肌超声评估方法及其临床应用情况进行总结。

1 膈肌超声的测量指标

1.1 膈肌厚度及变化率

一般取半卧位,床头抬高20°~40°,采用高频率(5~18MHz)探头,垂直于肋骨长轴置于腋前或腋中线第7~9肋间,在B模式下所见两条高回声线(胸膜和腹膜)之间的结构即为膈肌(图1),胸膜和腹膜的距离即为膈肌厚度。切换为M型超声分别测量吸气末及呼气末膈肌厚度。需要特殊强调,膈肌厚度是测量胸膜和腹膜之间的距离,而不是测量两条高回声线外缘的距离。膈肌厚度变化率可通过计算获得:膈肌厚度变化率=(膈肌厚度$_{呼气末}$-膈肌厚度$_{吸气末}$)/膈肌厚度$_{呼气末}$。膈肌厚度$_{呼气末}$<2 mm、膈肌厚度变化

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通信作者:刘朝阳,E-mail:midsunliu@aliyun.com

率<20%即可考虑膈肌麻痹[3]。

1.2 膈肌移动度

一般取平卧位,采用低频率(1~3MHz)探头,置于腋前线或锁骨中线与肋缘交界处,在 B 模式下,以肝脏或脾脏为声学窗,可见到覆盖在肝脏或脾脏表面的高回声线即为膈肌。切换为 M 型超声所见类似于“正弦曲线”的图形即为膈肌的运动轨迹,测量曲线最高点到基线的距离即为膈肌移动度(图 2)。在平静呼吸时健康成年男性的膈肌移动度为(1.8±0.3) cm,女性为(1.6±0.3) cm;当膈肌移动度<1.0 cm 时,可诊断膈肌功能障碍[4]。

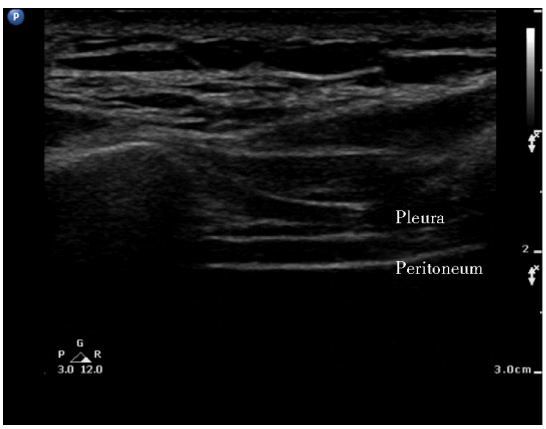

图 1 膈肌厚度超声图像

Figure 1 Ultrasound image of diaphragm thickness

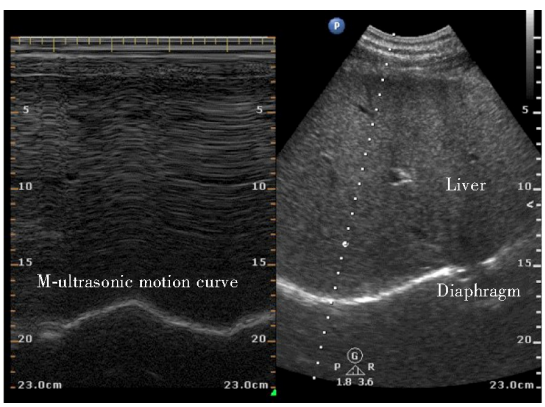

图 2 膈肌移动度超声图像

Figure 2 Ultrasound image of diaphragmatic excursion

1.3 膈肌收缩速度

膈肌收缩速度可通过膈肌移动度与吸气时间的比值来计算获得,测量方法同前述膈肌移动度,需同时记录膈肌完成此次移动所需要的时间,从基线(吸气开始时)到峰值的斜率(cm/s)即为膈肌收缩速度。Soilemezi 等[5]通过对 40 名健康成人膈肌收缩速度的测量,得出膈肌收缩速度为(1.3±0.4) cm/s,且无性别差异。

1.4 膈肌快速呼吸指数

快速浅呼吸指数(rapid shallow breathing index, RSBI)由 Yang 等[6]在 1991 年首次提出,通过呼吸频率与潮气量的比值得到,RSBI 用以预测机械通气患者脱机结局。膈肌快速呼吸指数(diaphragmatic rapid shallow breathing index, D-RSBI)源于 RSBI, 2016 年由 Spadaro 提出:D-RSBI = 呼吸频率/膈肌移动度[7]。Spadaro 等[7]及赵永华等[8]均证实 D-RSBI 比 RSBI 或膈肌移动度在预测撤机结局方面更准确。Abbas 等[9]的研究证实 D-RSBI 预测的阈值为 1.9 次/(min · mm),受试者工作特征曲线下面积为 0.97,灵敏度为 84.6%,特异度为 100.0%。

2 膈肌超声的临床应用

2.1 预测机械通气患者脱机结局

约 20%机械通气患者面临拔管失败,需要重新气管插管[10]。长时间机械通气可引起呼吸机相关膈肌功能障碍,很多研究已经证明膈肌功能障碍与脱机失败有密切关联[4,11]。因此撤机前对膈肌进行充分评估,确定合适的拔管时机尤为重要。Dinino 等[12]研究发现当膈肌厚度变化率≥30%时,撤机成功的灵敏度为 88%,特异度为 71%,并建议将膈肌厚度变化率≥30%作为撤机的临界值。Zhang 等[13]通过对 37 例慢性阻塞性肺疾病(chronic obstructive pulmonary disease, COPD)患者拔管结局预测的研究指出,当自主呼吸实验开始后 30 min 时的膈肌移动度大于 1.72 cm 时,预测拔管成功的特异度以及灵敏度分别为 83.3% 和 76%。Farghaly 等[14]指出,当自主呼吸实验期间膈肌移动度≥10.5 mm 时,预测拔管成功的特异度为 87.5%,灵敏度为 71.5%。而另外一项对 191 例成功通过自主呼吸实验患者的研究发现,膈肌移动度与拔管失败无关[15]。Whebell 等[16]的研究证实膈肌收缩速度有助于对撤机结局的预判。Huang 等[17]通过对一项纳入 40 例 80 岁及以上超高龄机械通气老年患者的研究,证实膈肌移动度和膈肌收缩速率是预测老年患者脱机结局的指标。赵永华等[8]通过对 110 例连续机械通气患者进行研究,证实 D-RSBI 预测的阈值为 1.5 次/(min · mm),灵敏度为 87%,特异度为 80%。另外还可通过膈肌超声与心脏超声、肺部超声进行联合预测脱机结局,Xu 等[18]的研究证实左心房压和肺部超声评分及膈肌功能障碍组成的预测模型在预测脱机结局方面有很好的准确性,受试者工作特征曲线下面积为 0.919,灵敏度和特异度分别为 91.7%和 82.7%,还首次提出了多因素的拟合方程,

logit (p) = −21.303+0.245×左心房压+1.046×肺部超声评分+3.009×单侧膈肌功能障碍。

2.2 协助诊断 COPD

肺功能是诊断 COPD 的金标准,但有一部分患者无法配合肺功能检查。可尝试通过膈肌超声来诊断 COPD。Scheibe 等[19]通过对 20 名健康志愿者和 60 例 COPD 患者的膈肌指标进行研究,发现膈肌移动度与第 1 秒用力呼气容积呈明显正相关,相关系数高达 0.85。彭浩等[20]相关研究显示:深呼吸时,通过膈肌移动度诊断 COPD 最佳截断点为 3.06 cm,灵敏度为 41.7%,特异度为 91.7%。另外一项纳入 124 例 COPD 患者的研究提出了“M 型阻塞指数”,通过第 1 s 用力呼气末与最大呼气末膈肌移动度的比值来计算,结果发现 M 型阻塞指数与 1 s 率高度相关(r=0.67),诊断 COPD 的阈值为 77%,其灵敏度为 83.3%,特异度为 96.6%[21]。

2.3 预测全身麻醉术后肌松残余

全身麻醉术后判断肌松残余的金标准是测量四个成串刺激 T4 与 T1 的比值(train of four stimuli ratio,TOFR),当 TOFR<0.9 时认为有肌松残余。但该操作有创且仪器昂贵,在国内并未常规开展,对全身麻醉术后肌松残余的判断主要依靠麻醉医师临床经验,而肌松残余可导致拔管后出现低氧、呼吸功能恢复不全、甚至再次插管。随着重症超声在临床的广泛应用,可通过膈肌超声评估全身麻醉术后肌松残余。吴雪梅等[22]通过对一项纳入 30 例全身麻醉手术患者的研究发现,呼气末膈肌厚度与 TOFR 呈正相关,且当 TOFR≥90%时,呼气末膈肌厚度显著增加。郎珈馨等[23]的研究得到类似的结论:在肌松残余患者中深呼吸膈肌移动度及膈肌厚度变化率均较低,且与 TOFR 显著相关。Cappellini 等[24]将膈肌增厚分数<36%作为诊断全身麻醉术后肌松残余的截断值,可发现部分 TOFR 无法监测到的隐匿性肌松残余。

2.4 预测术后肺部并发症

术后肺部并发症发生率为 25%~53%[25,26],是影响患者预后的重要因素。随着膈肌超声的逐渐成熟,可通过膈肌超声预测术后肺部并发症。Cavayas 等[27]在 115 例成人非急诊心脏手术的研究表明,术前深呼吸膈肌增厚分数小于 38.1%与肺部并发症发生相关(OR=4.9)。Spadaro 等[28]的研究发现术后 24 h 内膈肌移动度<10 mm 的患者较对照组肺部并发症发生率更高(65%和 25%)。岳红等[29]对 90 例行单侧肺切除术的患者进行研究,发现术后 24 h 平静呼吸状态下膈肌移动度<1 cm 的患者较对照组肺部并发症发生率更高(50.0%和 22.2%)。

2.5 评估康复训练效果

可通过膈肌超声监测膈肌厚度、膈肌移动度等指标对康复训练效果进行评估。Guzel 等[30]研究发现脊髓损伤患者膈肌厚度与康复前后的功能评分呈正相关。闫斌等[31]通过对 40 例重症脑出血患者进行研究,发现应用体外膈肌起搏器的患者膈肌移动度较对照组明显增大(2.91 cm 和 1.92 cm)。

3 小 结

综上,膈肌超声可实时客观地评估膈肌的形态学和功能,是一项非常有优势的评价膈肌功能的工具,在预测机械通气患者脱机结局,协助诊断 COPD、预测全身麻醉术后肌松残余、预测术后肺部并发症、评估康复训练效果等方面有潜在价值。相信随着超声技术不断提高以及相关研究的不断深入,膈肌超声必会有更加广阔的应用前景。

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