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·临床研究·

剪切波弹性成像技术对脑卒中偏瘫患者肌张力和肌肉硬度的评估价值研究*

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摘要 目的：研究应用剪切波弹性成像技术对脑卒中偏瘫患者肌张力、肌硬度进行评估的临床价值。**方法：**选取 2019 年 3 月到 2021 年 2 月在我院进行治疗的 79 例脑卒中偏瘫患者作为研究对象，应用超声仪检测所有研究对象健康侧（健侧）和患病侧（患侧）肱二头肌、肱肌和肱桡肌放松位和拉伸位下杨氏模量值，进行对比分析。**结果：**在放松位下，脑卒中偏瘫患者患侧肱二头肌和肱桡肌杨氏模量与健康侧肌肉相比无显著差异（$P>0.05$），而患侧肱肌杨氏模量显著低于健侧（$P<0.05$）。在拉伸位下，脑卒中偏瘫患者患侧肱二头肌、肱肌和肱桡肌杨氏模量均显著高于健康侧肌肉（$P<0.05$）；脑卒中偏瘫患者放松位与拉伸位肱二头肌、肱肌和肱桡肌杨氏模量差值也均显著高于健康侧肌肉（$P<0.05$）。此外，不同改良 Ashworth 肌张力分级的脑卒中偏瘫患者患侧肱二头肌、肱肌和肱桡肌杨氏模量均存在显著差异（$P<0.05$），并且患侧肱二头肌、肱肌和肱桡肌杨氏模量值随改良 Ashworth 肌张力分级升高而增加。**结论：**剪切波弹性成像技术可用于评估脑卒中偏瘫患者肌张力、肌硬度，以指导临床康复。

关键词：剪切波弹性成像技术；脑卒中；偏瘫；肌张力；肌肉硬度

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Evaluation Value of Shear Wave Elastography in the Evaluation of Muscle Tension and Muscle Stiffness in Stroke Patients with Hemiplegia*

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ABSTRACT Objective: To study the clinical value of applying shear wave elastography technology to assess muscle tension and muscle stiffness in stroke patients with hemiplegia. **Methods:** Seventy-nine stroke patients with hemiplegia who were treated in our hospital from March 2019 to February 2021 were selected as the research objects, and the healthy side (unhealthy side) and the diseased side (affected side) of the two heads of the brachial head of all the subjects were detected by ultrasound. The Young's modulus values of the muscles, brachialis and brachioradialis in the relaxed and stretched positions were compared and analyzed. **Results:** In the relaxed position, the Young's modulus of the biceps and brachioradialis on the affected side of stroke patients was not significantly different from that of the healthy side ($P>0.05$), while the Young's modulus of the affected side of the brachial muscle was significantly lower than that of the healthy side. The healthy side ($P<0.05$). In the stretching position, the Young's modulus of the biceps, brachialis and brachioradialis on the affected side of stroke patients with hemiplegia was significantly higher than that of the healthy side muscles ($P<0.05$); and the difference in Young's modulus of the biceps, brachialis and brachioradialis in the relaxed and stretched positions of stroke patients with hemiplegia was also significantly higher than that of the healthy side muscles ($P<0.05$). In addition, there were significant differences in Young's modulus of biceps, brachii and brachioradialis in stroke hemiplegia patients with different modified Ashworth muscle tension classifications ($P<0.05$), and the Young's modulus of the affected brachialis and brachioradialis muscles were significantly different. The modulus value increased with the increase of modified Ashworth muscle tone. **Conclusion:** Shear wave elastography technology can be used to evaluate the muscle tension and muscle stiffness of stroke patients with hemiplegia to guide clinical rehabilitation.

Key words: Shear wave elastography; Cerebral stroke; Hemiplegia; Muscle tension; Muscle hardness

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前言

脑卒中(cerebral stroke)是一种急性脑血管疾病,其发病原因在于患者脑部血管突然破裂或因血管阻塞导致血液不能流入大脑而引起脑组织损伤 [1,2]。偏瘫是脑卒中最常见并发症之一,肌肉痉挛是其主要临床表现,该现象本质是一种因牵张反射兴奋性增高所引起的速度依赖性肌肉张力增高的运动障碍。肌肉痉挛是不仅影响患者肢体运动能力的恢复,而且极大影响患者生活自理能力,及时有效的治疗肌肉痉挛对脑卒中偏瘫患者运动能力的恢复至关重要[3,4]。目前,主要使用改良 Ashworth 分级量表和改良 Tardieu 评分量表评估脑卒中偏瘫患者肌肉痉挛程度,这些主观评估肌肉痉挛的方法受制于临床评价的主观性而无法有效的指导临床治疗[5,6]。

剪切波弹性超声(shear wave elastography,SWE)是通过超声仪器测量可客观反映组织弹性的杨氏模量值一种超声检测方法,可用于评估肌肉张力 / 硬度[7,8]。之前已经有学者使用剪切波弹性超声评估帕金森病患肌肉张力，并发现 SWE 测量所得的帕金森患者肱二头肌和肱桡肌杨氏模量值显著高于健康对照研究对象[9]。然而,鲜有研究将 SWE 用于评估脑卒中偏瘫患者肌肉张力 / 硬度，本研究通过 SWE 测量脑卒中偏瘫患者健康侧和患病侧杨氏模量值并对比分析，以为 SWE 用于评估脑卒中偏瘫患者肌张力 / 硬度奠定理论基础。

1 资料与方法

1.1 研究对象

研究纳入 2019 年 3 月到 2021 年 2 月在我院进行治疗的 79 例脑卒中偏瘫患者,男 46 例,女 33 例,年龄 23-75 岁,平均年龄(55.38±13.18)岁,脑出血和脑梗死分别有 38 例和 41 例,平均病程(23.18±5.72)月,改良 Ashworth 肌张力分级 1 级、1+ 级、2 级和 3 级分别有 16 例、32 例、27 例和 4 例。纳入标准:第一,影像学确诊脑卒中偏瘫;第二,上肢改良 Ashworth 分级 1-3 级;第三,年龄 18~80 岁;第四,意识清醒,可配合医生指令完成肢体动作;第五,自愿加入本研究。排除标准:第一,交流障碍、智力障碍或不能与医生正常交流；第二，两侧肢体均瘫痪;第四,四肢残疾或其他既往四肢疾病史;第五,合并严重其他器官功能障碍或危及生命的疾病。

1.2 剪切波弹性超声

研究使用 Canon Aplio i900 超声诊断仪在放松位和拉伸位下检测并计算肱二头肌、肱肌和肱桡肌杨氏模量值,具体操作如下:患者取仰卧位,上肢完全伸展置于身体双侧;首先在二维超声模式下扫查以观察肌肉回声。待二维图片清晰稳定后开启剪切波弹性超声模式,将检测深度设定为 1.5~2.5 cm,检测区域设定为 10×10 mm 或直径 4 mm 圆形区域，记录系统自动计算出的各感兴趣肌肉的杨氏模量值。

1.3 统计学分析

采用 SPSS20.0 对数据进行分析,以(均值±标准差)计量资料,使用独立样本 t 检验比较两组间差异,使用单因素方差分析比较多组间差异,P<0.05 表示差异显著具有统计学意义。

2 结果

2.1 患侧与健侧肌肉放松位下杨氏模量值比较

在放松位下,患侧肱二头肌和肱桡肌杨氏模量与健康侧肌肉相比无显著差异(P>0.05);而患侧肱肌杨氏模量显著低于健侧,差异显著具有统计学意义(P<0.05)。具体如表 1 所示。

表 1 患侧与健侧肌肉放松位下杨氏模量值比较

Table 1 Comparison of Young's modulus values between the affected side and the contralateral muscle in the relaxed position

Groups	Healthy side	Diseased side	t	P
Biceps	14.72±6.51	14.43±6.39	0.627	0.342
Brachialis	17.82±6.84	13.87±6.82	7.261	<0.001
Brachioradialis	11.24±3.23	10.42±3.81	1.284	0.063

2.2 患侧与健侧肌肉拉伸位下杨氏模量值比较

在拉伸位下,患侧肱二头肌、肱肌和肱桡肌杨氏模量均显著高于健康侧肌肉,差异显著具有统计学意义(P<0.05)。具体如表 2 所示。

表 2 患侧与健侧肌肉拉伸位下杨氏模量值比较

Table 2 Comparison of Young's modulus values in the stretched position of the affected side and the contralateral muscle

Groups	Healthy side	Diseased side	t	P
Biceps	40.04±17.11	61.99±26.23	15.629	<0.001
Brachialis	48.90±16.15	104.89±40.38	12.428	<0.001
Brachioradialis	33.82±18.24	74.70±31.71	22.371	<0.001

2.3 患侧与健侧肌肉拉伸位 - 放松位下杨氏模量值差值比较

患侧拉伸位 - 放松位肱二头肌、肱肌和肱桡肌杨氏模量差值均显著高于健康侧,差异显著具有统计学意义(P<0.05)。具体如表 3 所示。

2.4 患侧拉伸部位杨氏模量与改良 Ashworth 肌张力的相关性

在拉伸位下,脑卒中患者患侧肱二头肌、肱肌和肱桡肌不同改良 Ashworth 肌张力分级的杨氏模量不同，差异显著具有统计学意义(P<0.05);患侧肱二头肌 \ 肱肌和肱桡肌杨氏模量随改良 Ashworth 肌张力分级升高而增加。具体如表 4 所示。

表 3 患侧与健侧肌肉拉伸位 - 放松位下杨氏模量值差值比较

Table 3 Comparison of the difference in Young's modulus between the affected side and the contralateral muscle in the stretched-relaxed position

Groups	Healthy side	Diseased side	*t*	*P*
Biceps	25.32±15.32	47.56±19.54	19.287	<0.001
Brachialis	31.08±14.82	91.02±35.21	13.191	<0.001
Brachioradialis	21.88±13.57	64.28±25.07	16.726	<0.001

表 4 患侧拉伸部位杨氏模量与改良 Ashworth 肌张力的相关性

Table 4 Correlation of the Young's modulus and the modified Ashworth muscle tension

Groups	Level 1	Level 1+	Level 2	Level 3	*F*	*P*
n	16	32	27	4		
Biceps	27.16±6.82	62.04±19.67	68.91±40.32	73.56±40.18	18.627	<0.001
Brachialis	39.82±15.62	95.82±36.72	134.51±42.82	237.80±43.88	19.672	<0.001
Brachioradialis	25.64±7.92	70.58±35.64	92.52±41.18	183.62±59.67	24.318	<0.001

3 讨论

脑卒中，又称中风，是全球第二大死亡原因，也是导致残疾的主要原因，已成为世界重大公共卫生挑战，相关研究提出：其治疗主要侧重于恢复流向大脑的血流和治疗中风引起的神经损伤[10]。缺血性脑血管病占脑卒中的 60 %～80 %，包括缺血性脑卒中和短暂性脑缺血发作，根据相关报道：虽然世界范围内脑卒中的发病率和患病率都在下降，但中国每年有 2.5 亿新脑卒中病例，而且这个数字还在增长，中国已成为脑卒中终生风险最高和疾病负担最重的国家[11,12]。肌肉痉挛是脑卒中患者最常见的并发症之一。流行病学统计数据显示[13,14]，脑卒中后，约 65 %患者会出现肌肉痉挛现象，而过度痉挛对脑卒中患者护理、运动功能的恢复及日常生活活动能力均有不利影响，且中风引起的瘫痪患者会出现肌肉萎缩，从而阻碍患者康复进程，导致其康复时间延长。

目前，临床上对于肌肉痉挛的治疗主要是通过注射肉毒毒素，然而其注射剂量则需要根据患者病情而定[15,16]。然而，目前临床上主要使用一些主观量表评价肌肉张力，比如改良 Ashworth 分级量表、改良的 Tardieu 评分量表以及 Clonus 评分量表，这些主观评价量表评价结果极易受病患和临床医生主观观念影响而无法准确指示病患肌肉痉挛程度。剪切波弹性超声是新发展的一种超声技术，是目前影像学诊断的热点，其原理主要利用超高速成像技术探测剪切波，然后利用编码技术将检测的组织弹性图显示出来，再利用计算机系统将感兴趣区域的杨氏模量值计算出来以表征检测组织肌肉张力[17-19]。

杨氏模量是描述固体材料抵抗形变能力的物理量，属于弹性模量，其数值越高即表示弹性越高，即越不容易发生形变。而肌肉硬度对肌肉的正常功能发挥具有重要作用，并且具有收缩和拉伸状态下均可被测量的属性，因此通过 SWE 测量所得肌肉的杨氏模量有助于评价肌肉功能状态[20-23]。本研究结果表明：脑卒中偏瘫患者在放松状态下仅患侧肱肌杨氏模量显著低于健侧，而在拉伸状态下患侧肱二头肌、肱肌和肱桡肌杨氏模量均显著高于健康侧肌肉，这与郭雪园[24]等人的研究结果一致，该研究应用 SWE 技术检测脑卒中患者肱二头肌肌硬度发现，脑卒中患者痉挛侧者肱二头肌经 SWE 测得的杨氏模量值高于非痉挛侧。而与本次研究结果不同的是，郭雪园等人研究发现，在放松状态下（屈肘 0 度）痉挛侧肱二头肌经 SWE 测得的杨氏模量值高于非痉挛侧，而本文研究却发现两者仅在拉伸位下才表现出差异，这可能与两次研究比较的统计量不同而引起（本研究使用均值，而郭雪园等人比较中位数）。

另外，本次研究中，不同改良 Ashworth 肌张力分级脑卒中患者患侧肱二头肌、肱肌和肱桡肌拉伸状态下经 SWE 测得的杨氏模量值存在显著差异，并且均随改良 Ashworth 肌张力分级增高而增高，这与和高慧[25]等人的研究结果一致，其结果表明：30 例脑卒中患侧肱二头肌和肱肌杨氏模量与改良 Ashworth 肌张力分级（MAS）均呈正相关，即肌肉改良 Ashworth 肌张力分级越高，其杨氏模量越大。相关研究显示：当肌肉处于拉伸状态下，神经反射活动受到抑制，进而导致神经元兴奋性增强，最终导致肌肉收缩能力收缩、肌肉硬度增加，因此本次研究在拉伸状态下所测得的肌肉杨氏模量值高于放松状态[26-28]。此外，随着患者病程的增加，脑卒中患者痉挛的肌肉组织中脂肪和肌肉含量均增加，这就导致患者肌肉节变下、肌肉机械特性和细胞结构发生变化，最终引起肌肉硬度增加，这也是脑卒中患者 SWE 测得的杨氏模量值随改良 Ashworth 肌张力分级增高而增高主要原因[29,30]。但需要指出的是本研究仍存在一些不足：第一，本次研究纳入样本量有限，研究结论仍需大样本临床数据验证；第二，研究未纳入改良 Ashworth 肌张力分级 3 级以上患者，所以仍不清楚 SEW 对入改良 Ashworth 肌张力分级 3 级以上患者临床应用价值。

综上所述，本研究结果表明：剪切波弹性成像技术可用于评估脑卒中偏瘫患者肱二头肌、肱肌和肱桡肌肌肉状态，该技术对指导脑卒中偏瘫患者临床康复具有重要意义。

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