

· 论著 ·

左心房容积指数与左心房前后径评价左心室舒张功能的一致性

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摘要 目的 探讨左心房容积指数(LAVI)与左心房前后径(LAAP)的关系以及二者评价左心室舒张功能的一致性。**方法** 选取我院2018年7月至2019年12月进行超声心动图检查患者315例,其中健康者68例(21.6%),高血压患者98例(31.1%),冠状动脉硬化性心脏病患者97例(30.8%),扩张型心肌病患者32例(10.2%),肺源性心脏病患者11例(3.5%),先天性心脏病患者9例(2.9%)。收集患者临床一般资料,超声心动图检测患者各项心脏指标,包括LAAP、左心房容积(LAV)、二尖瓣舒张早期峰值血流速度(MV E)、二尖瓣舒张晚期峰值血流速度(MV A)、二尖瓣环间隔部位舒张早期峰值速度(Septal e'),二尖瓣环侧壁部位舒张早期峰值速度(Lateral e')、三尖瓣反流峰速(TR)、左心室射血分数(LVEF)等。根据LVEF分为LVEF正常组(LVEF \geq 53%, $n=264$)和LVEF减低组(LVEF $<$ 53%, $n=51$),采用独立样本 t 检验比较2组左心室舒张功能指标的差异。采用Pearson或Spearman相关分析LAVI与LAAP的相关性;采用Kappa检验分析LAAP和LAVI评价左心室舒张功能的一致性。**结果** 与LVEF正常组比较,LVEF减低组患者LAAP、LAV、LAVI、E/e'及TR显著增大(均 $P < 0.001$),而Septal e'及Lateral e'显著减小(均 $P < 0.001$)。LAAP和LAVI水平呈正相关($r = 0.74, P < 0.001$)。LAAP和LAVI评价左心室舒张功能是否减低及分级的一致性均较强(均 $P < 0.001$)。**结论** LAAP与LAVI水平呈正相关;LAAP与LAVI评价左心室舒张功能是否减低和分级时一致性均较强。LVEF减低时,LAAP与LAVI相关性更高,LAAP与LAVI评价左心室舒张功能分级的一致性更强。因此,对于LVEF减低患者,当无法获得LAVI指标时,可用LAAP替代LAVI进行评估。

关键词 左心房容积指数;左心房前后径;左心室舒张功能;一致性

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Consistency of evaluating left ventricular diastolic function using left atrial volume index and left atrial anteroposterior diameter

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Abstract Objective To investigate the relationship between the left atrial volume index (LAVI) and left atrial anteroposterior diameter (LAAP) and their consistency in evaluating left ventricular diastolic function. **Methods** The study enrolled 315 patients who underwent echocardiography in our hospital between July 2018 and December 2019, including 68 healthy patients (21.6%), 98 patients with hypertension (31.1%), 97 patients with atherosclerotic heart disease (30.8%), 32 patients with dilated cardiomyopathy (10.2%), 11 patients with pulmonary heart disease (3.5%), and nine patients with congenital heart disease (2.9%). General clinical data were collected, and echocardiography was performed to detect various cardiac indicators, including LAAP, left atrial volume (LAV), mitral inflow-early diastolic (MV E), mitral inflow-late diastolic, septal early diastolic mitral annulus peak velocity (Septal e'), lateral early diastolic mitral annulus peak velocity (Lateral e'), tricuspid regurgitation peak velocity, and left ventricular ejection fraction (LVEF). Patients were divided into a normal LVEF group (LVEF \geq 53%, $n = 264$) and a reduced LVEF group (LVEF $<$ 53%, $n = 51$). An independent sample t test was used to compare the parameters of left ventricular diastolic function between the two groups. The correlation between LAVI and LAAP was analyzed using Pearson or Spearman correlation analysis. The kappa test was used to analyze the consistency of LAAP and LAVI in evaluating left ventricular diastolic function. **Results** LAAP, LAV, LAVI, MV E/e', and TR were significantly higher in the reduced LVEF group than in the normal LVEF group (all $P < 0.001$), while Septal and Lateral e' were significantly decreased (all $P < 0.001$). LAAP and LAVI were positively correlated ($r = 0.74, P < 0.001$). The results of the LAAP and LAVI evaluations of left ventricular diastolic function in all patients and groups showed that LAAP and LAVI were consistent in evaluating whether left ventricular diastolic function was reduced and graded ($P < 0.001$ for all). **Conclusion** LAAP and LAVI measured by echocardiography were positively correlated and

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showed strong consistency in evaluating whether left ventricular diastolic function was reduced and graded. The correlation between LAAP and LAVI was higher when the LVEF was reduced, and the consistency of LAAP and LAVI in evaluating left ventricular diastolic function was stronger. Therefore, in patients with a reduced LVEF, LAAP can be used instead of LAVI for evaluation when LAVI indicators cannot be obtained.

Keywords left atrial volume index; left atrial anteroposterior diameter; left ventricular diastolic function; consistency

左心室舒张功能对确保正常左心室充盈和足够的心输出量具有重要作用。高血压、射血分数保留性心力衰竭等心血管疾病早期仅表现为左心室舒张功能减低^[1-2]。因此,准确评价左心室舒张功能对评估病情和判断预后十分重要^[3-4]。超声心动图以实时、简便、无创等优势成为临床上舒张功能评价的首选影像学方法^[5-6]。2016年美国超声心动图学会关于左心室舒张功能指南^[7]中指出,左心房容积指数(left atrial volume index, LAVI)是评估左心室舒张功能的必要指标之一。但由于LAVI测量存在操作复杂、重复性较差、图像依赖性强等局限,临床应用受到一定的限制。左心房前后径(left atrial anteroposterior diameter, LAAP)以方便、快捷和重复性好的优势广泛应用于大型研究中^[8-9]。已有研究^[10-12]提出,LAAP在高血压、冠状动脉粥样硬化性心脏病及舒张性心力衰竭患者的诊治和预后判断中具有重要作用。目前,LAAP与LAVI之间的关系尚不十分明确,且LAAP与LAVI评价左心室舒张功能的一致性尚不清楚。本研究利用超声心动图探讨LAAP和LAVI的关系,并分析LAAP与LAVI评价左心室舒张功能的一致性。

1 材料与方法

1.1 研究方法

收集2018年7月至2019年12月于我院进行超声心动图检查患者的临床资料。纳入标准:(1)年龄 ≥ 18 岁;(2)窦性心律。排除标准:(1)心律失常、肥厚型心肌病、限制型心肌病、二尖瓣狭窄、中重度二尖瓣反流、二尖瓣钙化、中重度主动脉瓣反流、心脏移植、起搏器植入患者;(2)超声心动图图像质量不佳;(3)主动脉窦瘤及扩张的胸主动脉突入左心房内致左心房容积无法准确测量等。本研究获得我院医学伦理委员会批准[2021001ND(KT)-001-04]。

1.2 超声心动图检查

1.2.1 图像采集:采用GE Vivid E9型超声诊断仪,

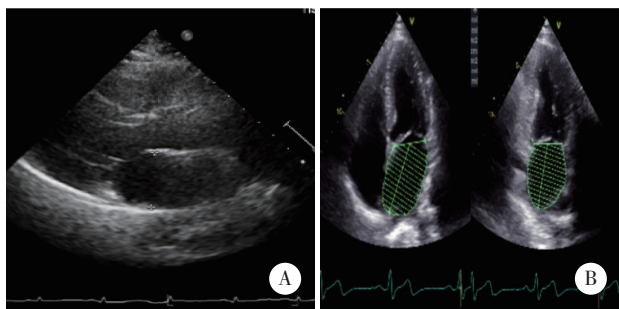
M5S探头,频率1.7~3.3 MHz,频率 >50 帧/s。嘱咐患者左侧卧位,同步连接胸前导联心电图,采集胸骨旁左心室长轴、心尖四腔、心尖两腔、心尖三腔切面动态二维图像,同时采集二尖瓣环组织多普勒频谱及二尖瓣多普勒血流频谱,所有测量值均采用3个心动周期的平均值表示。

1.2.2 图像分析:根据中华医学会中国成年人超声心动图检查测量指南^[14],测量并计算以下参数,(1)左心室舒张功能,LAAP(图1A)、左心房最大容积(left atrial volume, LAV,采用Simpson's双平面法于心尖四腔及两腔切面收缩末期测量,见图1B)、LAVI [$LAVI = LAV / \text{体表面积}(\text{body surface area, BSA})$]、二尖瓣舒张早期峰值血流速度(mitral inflow early diastolic, MV E)、二尖瓣舒张晚期峰值血流速度(mitral inflow late diastolic, MV A)、MV E/MV A比值(MV E/A)、二尖瓣环室间隔部位舒张早期峰值速度(septal early diastolic mitral annulus peak velocity, Septal e')、二尖瓣环侧壁部位舒张早期峰值速度(lateral early diastolic mitral annulus peak velocity, Lateral e')、三尖瓣反流峰速(tricuspid regurgitation peak velocity, TR),计算Septal e'与Lateral e'的平均值(e')、MV E与e'比值(E/e')。(2)左心室收缩功能,左心室舒张末内径(left ventricular end-diastolic dimension, LVEDD)、左心室舒张末容积(left ventricular end-diastolic volume, LVEDV)、左心室收缩末容积(left ventricular end-systolic volume, LVESV)、左心室射血分数(left ventricular ejection fraction, LVEF)。

1.3 左心室舒张功能评价

1.3.1 左心室舒张功能不全诊断:根据2016年美国超声心动图学会关于左心室舒张功能指南^[7],(1)LVEF正常时,左心室舒张功能不全诊断的4个指标:Septal e' <7 cm/s或Lateral e' <10 cm/s、E/e' >14 、LAVI >34 mL/m²、TR >2.8 m/s。2项以上指标超过临界值,提示左心室舒张功能不全;2项以上指标均未达临界值,提示左心室舒张功能正常;(2)LVEF减低

时,左心室舒张功能均减低。



A, LAAP; B, LAV.

图1 超声心动图测量方法

Fig.1 Measurements using echocardiography

1.3.2 左心室舒张功能不全分级:(1) $MV E/A \leq 0.8$ 且 $MV E \leq 50$ cm/s, 为左心室舒张功能不全 I 级;(2) $MV E/A \leq 0.8$ 且 $MV E > 50$ cm/s, 或 $MV E/A 0.8 \sim 2$, 为左心室舒张功能不全 II 级;(3) $MV E/A \geq 2$, 为左心室舒张功能不全 III 级。

1.4 统计学分析

采用SPSS 21.0软件进行统计分析。计数资料采用率(%)表示,2组比较采用 χ^2 检验。计量资料采用Shapiro-Wilk方法进行正态分布检验。符合正态分布的计量资料采用 $\bar{x} \pm s$ 表示,2组比较采用独立

样本 t 检验。采用Pearson或Spearman相关分析LAVI与LAAP的相关性。采用Kappa检验进行二分类变量间的一致性分析,一致性用Kappa值表示。采用Bland-Altman评估观察者内和观察者间重复性。 $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 患者一般临床指标比较

本研究共纳入315例患者,男165例,女150例;年龄 (56.7 ± 12.2) 岁,BSA (1.74 ± 0.18) m²,心率 (72.09 ± 12.50) 次/min,收缩压 (138.04 ± 27.99) mmHg,舒张压 (82.70 ± 12.88) mmHg。其中健康68例(21.6%),高血压98例(31.1%),冠状动脉粥样硬化性心脏病97例(30.8%),扩张型心肌病32例(10.2%),肺源性心脏病11例(3.5%),先天性心脏病9例(2.9%)。

根据中华医学会指南^[13]将患者分为LVEF正常组(LVEF $\geq 53\%$, $n = 264$)和LVEF减低组(LVEF $< 53\%$, $n = 51$)。LVEF正常组平均年龄 (56.8 ± 11.8) 岁,男128例,女136例,LVEF减低组平均年龄 (56.2 ± 14.3) 岁,男37例,女14例。2组患者一般临床指标比较见表1。

2.2 患者左心室舒张功能比较

表1 2组患者一般临床指标比较 ($\bar{x} \pm s$)

Tab.1 Comparison of basic clinical data between LVEF normal and reduced groups ($\bar{x} \pm s$)

Item	Total (n = 315)	Normal LVEF group (n = 264)	Reduced LVEF group (n = 51)
Age (year)	56.7 ± 12.2	56.8 ± 11.8	56.2 ± 14.3 ¹⁾
BSA (m ²)	1.74 ± 0.18	1.71 ± 0.22	1.80 ± 0.21 ¹⁾
HR (beat/min)	72.09 ± 12.50	70.58 ± 11.50	78.51 ± 14.40 ¹⁾
SBP (mmHg)	138.04 ± 27.99	143.62 ± 28.51	125.37 ± 22.32 ¹⁾
DBP (mmHg)	82.70 ± 12.88	85.21 ± 18.84	77.12 ± 14.32 ¹⁾
Hypertension [n (%)]	98 (31.1)	90 (34.1)	8 (15.7) ¹⁾
Coronary heart disease [n (%)]	97 (30.8)	88 (33.3)	9 (17.6) ¹⁾
Dilated cardiomyopathy [n (%)]	32 (10.2)	0 (0)	32 (62.7) ¹⁾
Pulmonary heart disease [n (%)]	11 (3.5)	10 (3.8)	1 (2.0)
Congenital heart disease [n (%)]	9 (2.9)	8 (3.0)	1 (2.0)

1) $P < 0.001$ vs. LVEF normal group. HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

结果显示,与LVEF正常组比较,LVEF减低组患者LAAP、LAV、LAVI、E/e'及TR显著增大(均 $P < 0.001$),而Septal e'及Lateral e'显著减小(均 $P < 0.001$),见表2。

2.3 全体患者 LAAP和LAVI的相关性分析

结果显示,患者LAAP与LAVI呈正相关($r = 0.74$,

$P < 0.001$)。

2.4 全体患者LAAP和LAVI评价左心室舒张功能是否减低及分级的一致性

结果显示,患者LAAP和LAVI评价左心室舒张功能减低时一致性较强(Kappa= 0.78, $P < 0.001$),见

表3。LAAP和LAVI评价左心室舒张功能分级时一致性也较强(Kappa=0.79, P < 0.001), 见表4。

2.5 2组患者LAAP和LAVI的相关性分析

结果显示, LVEF正常组与LVEF减低组LAAP与LAVI均呈正相关(r分别为0.53、0.79, 均P < 0.001)。

2.6 2组LAAP和LAVI评价左心室舒张功能减低及

分级的一致性分析

结果显示, LVEF正常组LAAP和LAVI评价左心室舒张功能减低和分级一致性均较强(Kappa值分别为0.67、0.68, 均P < 0.001), 见表5、6。LVEF减低组LAAP与LAVI评价左心室舒张功能分级一致性强(Kappa=0.97, P < 0.001), 见表7。

表2 2组患者左心室舒张功能指标比较 ($\bar{x} \pm s$)

Tab.2 Comparison of left ventricular diastolic function parameters between two groups ($\bar{x} \pm s$)

Item	Total (n = 315)	Normal LVEF group (n = 264)	Reduce LVEF group (n = 51)
LAAP (mm)	38.80 ± 6.18	37.29 ± 4.68	46.62 ± 7.70 ¹⁾
LAV (mL)	55.73 ± 21.02	50.53 ± 14.20	82.63 ± 28.89 ¹⁾
LAVI (mL/m ²)	32.14 ± 11.84	29.32 ± 8.15	46.71 ± 16.5 ¹⁾
Septal e' (cm/s)	6.48 ± 2.55	6.97 ± 2.40	3.95 ± 1.71 ¹⁾
Lateral e' (cm/s)	9.24 ± 3.45	9.78 ± 3.29	6.43 ± 2.84 ¹⁾
MV E (m/s)	0.74 ± 0.19	0.73 ± 0.17	0.83 ± 0.26 ¹⁾
MV E/A	1.16 ± 0.64	1.03 ± 0.39	1.86 ± 1.11 ¹⁾
MV A (m/s)	0.73 ± 0.22	0.76 ± 0.19	0.58 ± 0.28 ¹⁾
E/ e'	10.93 ± 5.95	9.44 ± 3.58	18.66 ± 9.55 ¹⁾
TR (m/s)	2.65 ± 1.01	2.01 ± 1.00	3.52 ± 1.04 ¹⁾

1) P < 0.001 vs. LVEF normal group.

表3 LAAP和LAVI评价左心室舒张功能减低的一致性分析

Tab.3 Consistency analysis of LAAP and LAVI evaluation of reduced left ventricular diastolic function

LAAP	LAVI			Total
	Normal	Reduced	Indeterminate	
Normal	178	1	4	183
Reduced	0	67	6	73
Indeterminate	25	2	32	59
Total	203	70	42	315

表4 LAAP和LAVI评价左心室舒张功能分级的一致性分析

Tab.4 Consistency analysis of LAAP and LAVI evaluations of left ventricular diastolic function grading

LAAP	LAVI					Total
	Normal	LVDD grade I	LVDD grade II	LVDD grade III	Indeterminate	
Normal	178	1	0	0	4	183
LVDD grade I	0	14	1	0	0	15
LVDD grade II	0	0	30	0	5	35
LVDD grade III	0	0	0	22	0	22
Indeterminate	25	0	2	0	33	60
Total	203	15	33	22	42	315

LVDD, left ventricular diastolic dysfunction.

表5 LVEF正常组LAAP和LAVI评价左心室舒张功能减低的一致性分析

Tab.5 Consistency analysis of LAAP and LAVI evaluation on left ventricular diastolic dysfunction in the normal LVEF group

LAAP	LAVI			Total
	Normal	Reduced	Indeterminate	
Normal	178	1	4	183
Reduced	0	16	6	22
Indeterminate	25	2	32	59
Total	203	19	42	264

表6 LVEF正常组LAAP和LAVI评价左心室舒张功能分级的一致性分析

Tab.6 Consistency analysis of LAAP and LAVI evaluation on grading of the left ventricular diastolic function in the normal LVEF group

LAAP	LAVI					Total
	Normal	LVDD grade I	LVDD grade II	LVDD grade III	Indeterminate	
Normal	178	1	0	0	4	183
LVDD grade I	0	0	0	0	0	0
LVDD grade II	0	0	13	0	5	18
LVDD grade III	0	0	0	3	0	3
Indeterminate	25	0	2	0	33	60
Total	203	1	15	3	42	264

LVDD, left ventricular diastolic dysfunction.

表7 LVEF减低组LAAP和LAVI评价左心室舒张功能分级的一致性分析

Tab.7 Consistency analysis of LAAP and LAVI evaluation on grading of left ventricular diastolic function in the reduced LVEF group

LAAP	LAVI			Total
	LVDD grade I	LVDD grade II	LVDD grade III	
LVDD grade I	14	1	0	15
LVDD grade II	0	17	0	17
LVDD grade III	0	0	19	19
Total	14	18	19	51

LVDD, left ventricular diastolic dysfunction.

2.7 LAAP和LAV测量重复性检验

LAAP和LAV观察者间重复性检验结果显示, 偏倚为0.4 mm [95% 一致性界限 (limits of agreement, LOA) -0.6~1.3 mm]、1.7 mL (95% LOA -6.5~8.4 mL)。LAAP和LAV观察者内重复性检验结果显示, 偏倚为-0.2 mm (95% LOA -1.0~1.2 mm)、1.5 mL (95% LOA -5.7~ 8.8 mL)。可见LAAP和LAV观察者间及观察者内重复性均良好。

3 讨论

左心室舒张功能不全通常是由于左心室松弛受损, 左心室僵硬增加, 伴或不伴弹性恢复力增

加, 从而导致心脏充盈压升高的结果。左心室舒张功能不全与患者突发心力衰竭、预后不良, 甚至和一般人群的全因死亡率显著增高均有关^[14-16]。因此, 准确评价左心室舒张功能尤为重要。

超声心动图是临床评价左心室舒张功能的常用方法, 可早期发现高血压、肥胖、冠状动脉粥样硬化性心脏病等患者的心功能异常。超声心动图评估左心室舒张功能的指标主要包括: (1) MV E/A, 用于确认充盈类型 (正常、松弛受损、假性正常化和限制性充盈), 其测量具有良好的可行性和重复性, 但影响因素较多, 易受心律及左心室前后负荷等因素影响; (2) e', 左心室松弛受损时e' 减小, 与血流多普

勒相比,其对负荷依赖性较小,但在冠状动脉粥样硬化性心脏病、二尖瓣环钙化或心包疾病患者中准确性受影响;(3) E/e' ,常规用于估测左心室充盈压。具有良好的可重复性和可行性,但受心包疾病、二尖瓣环钙化的影响较大;(4) LAVI,可用于反映升高的左心室充盈压随着时间变化产生的累积效应,左心房容量增加对于死亡、心力衰竭及心房颤动等具有预测价值;(5) TR,应用连续多普勒获取TR,主要用于估测肺动脉收缩压,在无肺动脉疾病时,肺动脉收缩压用于评估左心房压力,具有预后价值;但此指标是间接估测肺动脉压力,当三尖瓣反流较少时,无法估测肺动脉压力^[17]。

左心房壁可描述为上壁、下壁、外侧壁、内侧壁(房间隔)、前壁和后壁。因此左心房径线的测量可分为上下径、左右径以及前后径。左心房壁存在左、右肺静脉4个入口,以及前壁向前突出的左心耳,因此,进行测量左心房各个径线及容积时需避开心房壁的各个开口^[18]。当左心室舒张功能障碍时,心肌松弛能力受损,左心房压力增高,左心房体积增大,左心房各个径线可不同程度增大^[19]。近年来,CANCIELLO等^[20]在70例患者中证实了通过非线性方程利用LAAP推导计算所得的LAV预测椭球体法评估的LAV效能最大。但是,椭球体法可能更容易受到左心房几何形态假设的影响,可能会严重低估实际的LAVI,影响左心房增大截点值的准确性。另外,陈琳琳等^[21]证实左心房3个径向的径线平均值对应的内径指数,用来诊断双平面法所测LAVI是否增大的准确性最高。临床实际工作中患者量较大,因此LAAP实用性更强。

2016年美国超声心动图学会关于左心室舒张功能指南指出,LAV常用的测量方法有Simpson's双平面法和面积-长度法^[7]。这两种测量方法操作复杂,用时较长,临床工作及研究中常受到限制。因此,LAAP具有方便、快捷及重复性好等优点,在临床上广泛用于评价左心房的大小。另外,以往研究^[22-24]中的超声数据常仅提供LAAP而无容积。因此明确LAAP和LAVI之间的相关性及二者在评价左心室舒张功能时的一致性具有重要的价值。本研究结果显示,LAAP和LAVI呈正相关;LVEF减低患者二者相关性更加显著。LAAP和LAVI评估左心室舒张功能不全减低和分级结果也具有很强的一致性。另外,

本研究对LVEF正常组和LVEF减低组分别进行分析的结果显示,LVEF减低组LAAP和LAVI评估左心室舒张功能不全分级具有强一致性($Kappa=0.97, P < 0.001$)。

综上所述,超声心动图中LAAP与LAVI水平呈正相关;LAAP与LAVI评估左心室舒张功能是否减低和分级一致性均较强。LVEF减低时,LAAP与LAVI相关性更强,LAAP与LAVI评价左心室舒张功能分级的一致性也更强。因此,对于LVEF减低患者,当无法获得LAVI指标时,可用LAAP替代LAVI进行评估。本研究存在一定局限性:(1)患者为随机选取,包含心脏疾病种类有限;(2)排除了一些评价舒张功能时需要提供特殊参数的心血管疾病患者,例如心房颤动、二尖瓣功能不全、左束支传导阻滞及肥厚型心肌病等;(3)样本量及收集的临床指标有限,LVEF减低患者比例相对较低,因此今后需扩大样本量进一步验证。

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