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Оценка показателей глобальной продольной деформации левого предсердия в диагностике кардиотоксичности

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АННОТАЦИЯ

Широкий спектр крайне эффективных химиотерапевтических препаратов обладает негативным влиянием на сердечно-сосудистую систему, нивелируя успехи онкологического лечения. В связи с этим ранняя диагностика кардиотоксичности имеет крайне важное значение, позволяя вовремя применять профилактические и лечебные мероприятия.

Определение фракции выброса левого желудочка с помощью эхокардиографии — базовый неинвазивный инструментальный метод оценки сердечной функции и главный ориентир в вопросах диагностики сердечной дисфункции на фоне химиотерапии. Однако при субклиническом поражении показатель долго может оставаться нормальным, а также иметь выраженную межоператорскую вариабельность и зависимость от объёмной нагрузки. Специалисты постоянно находятся в поиске оптимальных эхокардиографических параметров, позволяющих диагностировать сердечную дисфункцию на ранних стадиях. Анализ глобальной продольной деформации левого предсердия представляется перспективным методом для данных целей. Большое количество накопленных данных позволяет говорить о том, что левое предсердие является не просто камерой-кондуитом, а отражает давление наполнения левого желудочка, являясь чувствительным маркером его систолической и диастолической дисфункции.

В обзоре представлен анализ имеющихся на настоящий момент исследований по применению методики оценки глобальной продольной деформации левого предсердия в диагностике сердечной дисфункции на фоне применения кардиотоксичных препаратов.

Ключевые слова: левое предсердие; кардиоонкология; кардиотоксичность; стрейн; эхокардиография; сердечная дисфункция; антрациклины.

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Left atrial longitudinal strain analysis in diagnostic of cardiotoxicity

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ABSTRACT

A wide range of extremely effective chemotherapy drugs has a negative effect on the cardiovascular system, leveling oncological treatment success. Early diagnosis of cardiotoxicity is very important, allowing timely application of preventive and therapeutic measures. Left ventricular ejection fraction evaluation using echocardiography is the basic non-invasive instrumental method to assess cardiac function and the main guideline in cardiac dysfunction diagnosis during chemotherapy. However, if dysfunction is subclinical, the ejection fraction can remain normal for a long time, and also has a pronounced inter-operator variability and dependence on volumetric load. Specialists are constantly in search of optimal echocardiographic parameters that allow early-stage cardiac dysfunction diagnosis. Analysis of the global longitudinal deformation of the left atrium seems to be a promising method for these purposes. A large amount of accumulated data suggests that the left atrium is not just a conduit chamber, but a reflection of the filling pressure of the left ventricle, being a sensitive marker of its systolic and diastolic dysfunction. This review presents an analysis of currently available studies on applying the methodology for assessing global longitudinal deformation of the left atrium in cardiac dysfunction diagnosis in the use of cardiotoxic drugs.

Keywords: left atrial function; transthoracic echocardiography; cardiotoxic agent; left ventricular dysfunction; anthracycline.

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左心房整体长轴应变参数在心脏毒性诊断中的评价

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简评

一系列极其有效的化疗药物对心血管系统有负面影响，从而找平了癌症治疗的成功。因此，心脏毒性的早期诊断非常重要，可以及时采取预防和治疗措施。

使用超声心动图测定左心室射血分数是评估心脏功能的基本无创仪器方法，也是化疗期间诊断心功能不全的主要指南。然而，在亚临床病变中，该指数可能在很长一段时间内保持正常，并且还具有明显的操作者间变异性和对体积负荷的依赖性。专家们一直在寻找最佳的超声心动图参数，以便在早期阶段诊断出心功能失调。左心房整体长轴应变的分析似乎是对于这些目的的有前途的方法。大量积累的数据表明，左心房不仅仅是一个导管，而是反映了左心室的充盈压力，是其收缩和舒张功能障碍的敏感标志。

本综述分析了目前关于使用心脏毒性药物诊断心脏功能障碍的左心房整体长轴应变的现有研究。

关键词：左心房；心脏肿瘤学；心脏毒性；心肌劳损；超声心动图；心功能不全；蒽环类药物。

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绪论

近几十年，现代肿瘤学的进步显着提高了癌症患者的生存率。新的化疗药物不断积极研发并投入临床，肿瘤疾病的早期诊断和检测水平不断提高。另一方面，化疗的短期和长期效果对癌症患者的死亡率有显著影响，包括对心脏病和血管疾病[1]。根据流行病学研究，在成功接受肿瘤治疗的患者中，随着时间的推移，发生心血管疾病及其并发症的风险开始超过癌症复发的风险[2]。在分析儿童癌症幸存者的心血管死亡率时，死亡率水平在他们达到60岁后显著增加，这表明了疾病本身及其治疗后果的延迟效应[3]。因此，本组患者越来越成为全科医生和心脏病专家关注的焦点。这不仅是由于人口普遍老龄化，还因为大多数癌症患者的年龄在65岁及以上[4]，因此不仅是患者，还有整个医疗保健系统都增加了负担，其中就包括财务负担[5]。

随着时间的推移，医学界已经认识到本组患者需要更多学科的方法。心脏病学是一门相对较新的学科，专注于接受各种类型癌症治疗的患者，而这些治疗会对心血管系统带来潜在风险。这一快速发展的医学领域，其系统方法侧重于对接受化学治疗和放射治疗的患者进行筛查、风险分层、预防、随访和治疗[6]。心脏毒性不仅限于对左心室（LV）的损害，它可以表现为节律紊乱、心包和心脏瓣膜、冠状动脉、动脉和肺动脉高压的损害[7]。同时，一些化疗药物会对心血管系统造成快速和早期的损害，而其他药物的副作用在多年后会随着时间的推移而出现[8]。研究表明早期发现心功能不全（CD）迹象的重要性，这反过来又有助于开始及时纠正并防止对心脏造成不可逆的损害[9]。超声心动图（ECHO）在此情况诊断中起主导作用。

超声心动图对诊断心脏毒性

ECHO是心脏病学的基本研究方法。由于其可用性和安全性，使用二维超声心动图测量LV射血分数（EF）仍然是诊断心脏毒性表现的主要工具之一。但是它具有许多局限性：操作员之间的可变性和图像质量对结果的影响。EF指数与容积有关，这对于癌症患者来说往往变得至关重要，因为癌症患者通常在呕吐、腹泻和食欲不振的背景下处于低血容量状态[10]。直到补偿机制完全耗尽并对心肌造成重大损害前，LVEF实际上不会改变，这使得使用其孤立评估难以诊断早期心脏毒性[11]。

使用散斑跟踪二维超声心动图（2D STE：2D Speckle Tracking Echocardiogram）和确定LV的整体纵向应变（global longitudinal strain）指标可以诊断LV功能的最小变化，从而提高CD诊断，包括亚临床[12]，然而，该指标也取决于前负荷[13]。LV应变在连续测量中具有良好的重现性，可能有助于识别发生心脏损伤的风险组、动态监测，并有助于早期心脏保护治疗的决策[12, 14]。

目前，在肿瘤学心脏保护中存在以应变为导向的策略概念[15]。从2014年到2019年，一项关于该主题的随机对照多中心研究（化疗对改善心血管预后的应变监测——Strain Surveillance of Chemotherapy for Improving Cardiovascular Outcomes, SUCCOUR）[10]纳入331名接受蒽环类药物治疗的患者，但结果相互矛盾。在研究结束时，应变导向组和常规心脏保护策略组的EF差异无统计学意义，因此未达到主要终点。亚组分析显示，在LV应变控制下进行心脏保护治疗可将LVEF显著下降至异常范围[16]。这些结果强调需要进一步研究以确定LV应变是否能比EF更好地识别将受益于心脏保护治疗以预防癌症治疗相关CD[10]的选定患者群体。

2021年，英国超声心动图学会（British Society of Echocardiography）和英国心血管肿瘤学会（British Cardio-Oncology Society）定义了以下心脏毒性的超声心动图标准：LVEF比初始值下降10%及以上或小于50%的绝对值（LVEF从50到54%被认为是临界值，需要更多信息来决定是否存在功能障碍）。关于LV应变指数，下降小于15%被认为是病理性的，而它的下降不应孤立地解释：有必要考虑临床表现和其他综合体中指标的变化数据（如实验室标记和其他成像技术的结果）[17]。指南的作者强调，尽管对收缩功能进行了整体ECHO评估，但仍有“灰色地带”可以对应于亚临床CD和规范。

舒张功能和心脏毒性

对接受心脏毒性治疗的患者还建议进行舒张功能评估，但其预后作用仍不明确。在一般人群中，心血管事件的风险在存在舒张功能障碍的情况下显著增加，其特征是LV充盈压增高[18]。对于一组癌症患者，研究结果并不一致，通常受到样本量小和化疗方案异质性高的限制。

根据M. Nagiub及团队的荟萃分析[19]，他们研究了舒张参数在检测多柔比星治疗诱发的心肌病中的预测能力，多普勒参数为E（$p=0.003$），E/A比值（$p<0.0001$）、侧向e’（$p<0.005$）和s’（$p=0.01$）， 在长期随访期间，在很大程度上与该组患者的收缩功能恶化有关。然而，作者指出，在荟萃分析中纳入的17项研究中，只有4项经过优化设计，并对舒张参数进行了完整的系列评估。

J.N. Upshaw及团队[20]进行的一项前瞻性研究还检查了蒽环类药物联合/不联合曲妥珠单抗治疗期间舒张压参数的变化。该研究的参与者（n=362）表示，在治疗第6个月时，舒张功能持续恶化，E/A比值、侧向和间隔e’速度下降，以及E/e’比值增加（$p<0.01$）。1年后60%的病例出现舒张功能异常，2年后为70%，3年后为80%。损伤与随后的LVEF下降和LV纵向应变的恶化有关。

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作者得出的结论是，在现代的乳腺癌治疗中，舒张功能存在中度持续恶化，这与随后发生CD风险较小有关。

根据R. I. Mincu及团队对13项研究（n=892）进行的荟萃分析结果[21]，在接受蒽环类药物且既往没有心脏病的患者中，治疗对E/A比值（p<0.001）有适度影响，而e'和E/e'没有变化。荟萃分析的作者指出了，这些研究的多重局限性，它们的异质性导致高偏倚风险，并且需要使用新的超声心动图参数（如舒张压）对大样本进行随机研究。

上述对接受心脏毒性治疗的患者舒张功能的研究结果表明，需要对癌症患者进行更仔细的监测，以发现异常的舒张功能，并进行进一步的研究。

综上所述，我们可以说，与使用心脏毒性药物相关的CD超声心动图诊断仍存在问题、差距和“灰色地带”，特别是其早期表现，其诊断对于防止对心肌造成不可逆转的损害最为重要。

左心室功能和心脏毒性

心脏成像专家一直在寻找可用的可重复技术和指标，这些技术和指标可以常规应用于临床实践，并以最小的操作者间变异性持续进行连续评估，并且尽可能与角度和容积无关。应该注意，研究人员对左心房（LA）功能的兴趣日益浓厚。大型研究表明LA大小在心力衰竭患者中具有独立的预测价值，并使其被视为一般人群中可能的国际预后指标[22，23]。随着侵入性技术、3D和斑点追踪超声心动图的发展，人们认识到LA不仅仅是填充LV的导管室。LV和LA之间的紧密动态连接使其成为一种反映LV功能并通过储层、导管和收缩阶段调节其充盈压力的镜子[24，25]。通过改变其自身的功能和机制，LA可以适应LV顺应性的变化[26]。在近十年中，关于使用斑点追踪超声心动图评估LA应变的出版物数量迅速增加。获得的数据用于评估舒张功能和评估心房本身的功能[27，28]。该方法与心脏计算机断层扫描和磁共振成像数据以及侵入性测量数据具有良好的相关性[29-31]。尽管LA应变并非完全独立于前负荷，但前负荷条件对LA应变的影响似乎比对容积的影响要小[32]。同时，LA收缩的不同阶段表现出各自的特点：例如，通过非侵入性评估，储层和收缩功能下降直至出现心力衰竭症状、LA扩张和LV充盈压升高，从而使其有可能在临床前阶段诊断舒张功能障碍的存在[33]。在近10年中，越来越多的证据表明LA整体纵向应变（GLS）参数的变化是LV舒张功能障碍的唯一标志[28，34]。可以说LA应变是衡量LV顺应性的指标，当整体超声心动图参数仍正常时，它成为LA功能障碍的重要指标和舒张功能障碍的早期标志物[35]。根据F. Pathan及团队的荟萃分析[36]，其中纳入30项研究（2038名健康志愿者），迄今为止已确定以下整体纵向LA应变指标的正常水平：储层应变（εR）为39%（95%置信区间38-41）、收缩应变（εCT）为18%（95%置信区间16-19），并导管应变（εCD）为23%（95%置信区间21-25）。

在心脏肿瘤成像中，LA功能长期处于阴影中，因为关注焦点完全转移到了LV。间接地，在舒张功能分析中评估其功能（容积）。近年来，LA应变分析技术引起了心脏毒性诊断专家的密切关注。

2013年对LA应变和心脏毒性进行了首次研究。I. Monte及团队[37]对一小部分接受米托蒽醌治疗的多发性硬化症患者（n=20）进行了研究。该研究为前瞻性研究，研究显示到治疗结束时整体LA应变减少（10个月 vs 0个月：15.2±12.5 vs 20.2±11.1，p<0.05）。进一步的研究主要集中在蒽环类和表皮生长因子抑制剂中最具心脏毒性的药物，但也对其他组进行了研究。例如，A. Sonaglioni及团队的研究[38] 纳入接受贝伐单抗（血管内皮生长因子的生物活性抑制剂）治疗肠癌的患者（n=28）。超声心动图在治疗开始前进行，然后在3个月和6个月后测量正负LA应变（εCD和εCT）。6个月后，各项指标在统计学上没有显著性差异。在一项亚组分析中，其中一个因心脏毒性而发展为CD，结果发现，在CD组中，表明LV充盈压增高的超声心动图基线特征在统计学上显著更高：更高的E/e'比值（p=0.01）和更低的基线εCD（p=0.007）。相应已确定的变化可能是CD发展的预测因素。J. Meloche及团队[39] 在一项前瞻性研究（n=51）中获得了类似的数据，在使用蒽环类药物和曲妥珠单抗治疗期间，符合心脏毒性标准的9名患者的基线εR（50.0±9.6 vs 45.6±4.9%，p=0.058）和εCT（30.1±8.0 vs 24.3±4.6%，p=0.008）较低。注意到其中7人εCT增加，可能是对LV功能降低的补偿。一般来说，在这组患者中，在所有治疗阶段，LA功能均出现早期下降：εCT——到第3个月（29.5±7.6和27±8.5，p=0.008），εR（49.7±8.8和44.4±10.4%，p<0.001）和εCT（20.2±4.6和17.3±5.3%，p<0.001）——到第6个月。

R. Emerson及团队（n=51）[40]、M. Laufer-Perl及团队（n=40）[41]、S. Moustafa及团队（n=68）[42]、J. Moreno及团队（n=52）[43]的研究证明在蒽环类药物治疗期间，无论是否添加曲妥珠单抗，LA应变都有统计学意义的降低。E.Setti及团队（n=64）[44] 在他们的研究中发现，εR和LA容积可以预测曲妥珠单抗治疗期间6个月随访期间的EF趋势。

相反，S. Moustafa及团队（n=56）[45]和Y. Anqi及团队（n=40）[46]的研究并未揭示LA功能参数在化疗治疗背景下的差异。如果在第一项研究[45]中这可以通过以下事实来解释：所研究的药物属于酪氨酸激酶抑制剂组，对心肌没有直接毒性作用，但具有血管毒性，而在第二项研究[46]中，作者指出蒽环类药物治疗为低剂量，尽管LVEF（p<0.05）和LV应变（p<0.05）的降低

达到了统计学意义。A.T. Timóteo及团队[47]在他们的研究（n=77）中也发现LA应变没有差异，但显示其下降趋势最大的参数是ƐCT，这与J. Meloche及团队[39]以及M. Laufer-Perl及团队[41]的数据一致。H. Park及团队（n=72）[48]的一项回顾性研究纳入已接受蒽环类药物治疗的患者，随后将其分为发生（n=13）和未发生（n=59）CD两组。超声心动图基线特征没有差异。化疗结束时，两组的LV应变（p=0.002）和ƐR（p<0.001）均显著降低。在ROC分析中，预测未来CD的最佳ƐR降低为11.7%，其敏感性和特异性优于LV应变。D. di Lisi及团队[49]在他们的研究（n=102）中，首次结合LA应变评估，确定了LA僵硬度指数（一种新的潜在预测指标——E/e'与ƐR比值）。所有患者均未出现CD的临床体征，但53%的病例检测到亚临床功能障碍，因此将患者分为2组（有和没有出现功能障碍）。在两组中，观察到LA僵硬度指数的早期增加（p<0.0001）和ƐR的降低（p<0.0001）。作者得出结论，这些指标可以比LV应变更准确地识别早期亚临床CD[49]，在这一点上，他们的结论与H. Park及团队的工作[48]一致。

值得一提的是两项横断面研究，其中研究了蒽环类药物治疗对儿童癌症幸存者LA功能的长期影响。V.W. Li及团队的研究（n=26）[50]纳入了儿童时期接受蒽环类药物治疗的男性（未接受化疗的时间为14.2±5.4年），将其表现与年龄匹配的健康受试者进行了比较。癌症患者组的最大（p=0.009）和最小（p=0.017）LA容积和ƐCT（p=0.011）值在统计学上显著降低。作者认为，以收缩功能下降为特征的LA重塑是儿童时期使用蒽环类药物引起的LA纤维化的结果。

R.W. Loar及团队的研究[51]比较了2组按性别和年龄匹配的患者：未接受化疗超过1年的癌症患者（n=45）和一组健康个体（n=45）。在第一组中，与对照组相比，ƐR值（p=0.04）在统计学上显著降低。亚组分析了11例具有最低四分位数ƐR值的患者。无论化疗持续时间和蒽环类药物剂量如何，该组中所有患者的年龄均显著高于前三四分位数患者（p=0.001），舒张功能和LA应变没有变化。因此，年龄是癌症治疗后LA功能下降的唯一独立预测因子（p<0.001）。N.R. Patel及团队[52]在一项回顾性观察研究中获得了相反的结果：在55名儿童中，仅在12岁以下的患者组中发现化疗前后LA应变的统计学显著差异（p=0.01）。因此，持续治疗对LA功能的长期影响尚未确定，这需要长期的观察性研究。

总之，引用M. Tadic及团队（n=92）[53]的一项回顾性研究的数据，该研究显示与具有可比特征的对照组相比，在开始化疗之前，肿瘤患者LA的储层和导管功能下降（p<0.001）。作者推断癌症本身可能与LA功能下降有关，无论其他特征如何，并为这种关系提出了几种假设和的潜在机制：炎症、生物激素系统的激活、血管活性肽和细胞因子的循环、本组患者的吸烟率以及疾病影响下的生活方式改变（特别是活动减少）。

综上所述，可以注意到许多研究主要涉及女性，其LA应变在人群中的初始值超过了男性[54]。LA应变测量本身具有以下优点：与角度无关； 在四腔位置观察LA不易受到肺叶的干扰； 图像伪影和混响的发生频率较低[55]。但该方法也有其缺点：LA是一个薄壁腔室，难以追踪心内膜；研究人员还经常“切断”LA的投影，缩短其纵向尺寸。不要忘记指数对帧速率和前负荷的依赖性（尽管低于LV和EF应变），以及对分析软件的需求。然而，该方法的简单性和易于证明其预后和诊断价值使其成为心脏肿瘤学家手中的有用工具。

在哪些情况下LA应变的连续测量将提供最大的优势并补充超声心动图图像仍有待确定：用于诊断早期亚临床心脏毒性或化疗的延迟效应，或者将有助于决定是否启动治疗并监测其有效性。回答这些问题需要对大量患者群体进行前瞻性对照研究。

随着新型化疗药物的积极涌现，心脏病学面临新的挑战。例如，不可逆的酪氨酸激酶抑制剂依鲁替尼与心房颤动的高发病率相关，A. Singh及团队[56]的最近一项研究表明，LA应变在这组患者中具有良好的预测价值。

研究的局限性

需要注意观察的局限性：观察性研究大多数为回顾性，并且在小样本上进行，其特点是化疗方案的异质性相当高，而一些患者接受了胸部区域的放射治疗，这可能导致超声心动图参数的变化。

结论

因此，通过分析现有研究的数据，我们可以讨论评估LA应变在接受具有心脏毒性作用的化疗患者中的潜在效用。

超声心动图诊断的潜力不断发展，可以说LA应变的评估是心脏病学中一种很有前途和有用的方法。

ADDITIONAL INFORMATION

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СПИСОК ЛИТЕРАТУРЫ

1. Herrmann J., Lerman A., Sandhu N.P., et al. Evaluation and management of patients with heart disease and cancer: cardio-oncology // Mayo Clin. Proc. 2014. Vol. 89, № 9. P. 1287. doi: 10.1016/J.MAYOCP.2014.05.013

2. Okwuosa T.M., Anzevino S., Rao R. Cardiovascular disease in cancer survivors // Postgrad Med J. 2017. Vol. 93, № 1096. P. 82–90. doi: 10.1136/POSTGRADMEDJ-2016-134417

3. Fidler M.M., Reulen R.C., Henson K., et al. Population-based long-term cardiac-specific mortality among 34 489 five-year survivors of childhood cancer in Great Britain // Circulation. 2017. Vol. 135, № 10. P. 951–963. doi: 10.1161/CIRCULATIONAHA.116.024811

4. Miller K.D., Nogueira L., Mariotto A.B., et al. Cancer treatment and survivorship statistics, 2019 // CA Cancer J Clin. 2019. Vol. 69, № 5. P. 363–385. doi: 10.3322/CAAC.21565

5. Valero-Elizondo J., Chouairi F., Khera R., et al. Atherosclerotic cardiovascular disease, cancer, and financial toxicity among adults in the United States // JACC CardioOncology. 2021. Vol. 3, № 2. P. 236–246. doi: 10.1016/J.JACCAO.2021.02.006

6. Tajiri K., Aonuma K., Sekine I. Cardio-oncology: a multidisciplinary approach for detection, prevention and management of cardiac dysfunction in cancer patients // JJCO Japanese J Clin Oncol. 2017. Vol. 47, № 8. P. 678–682. doi: 10.1093/jjco/hyx068

7. Chang H.M., Moudgil R., Scarabelli T., et al. Cardiovascular complications of cancer therapy: best practices in diagnosis, prevention, and management: part 1 // J Am College Cardiol. 2017. Vol. 70, № 20. P. 2536–2551. doi: 10.1016/j.jacc.2017.09.1096

8. Armstrong G.T., Ross J.D. Late Cardiotoxicity in aging adult survivors of childhood cancer // Prog Pediatr Cardiol. 2014. Vol. 36, № 1–2. P. 19. doi: 10.1016/J.PPEDCARD.2014.09.003

9. Lati G., Heck S.L., Ree A.H., et al. Prevention of cardiac dysfunction during adjuvant breast cancer therapy (PRADA): a 2×2 factorial, randomized, placebo-controlled, double-blind clinical trial of candesartan and metoprolol // Eur Heart J. 2016. Vol. 37, № 21. P. 1671–1680. doi: 10.1093/eurheartj/ehw022

10. Lopez-Mattei J.C., Hassan S. The SUCCOUR trial: a cardiovascular imager's perspective — American College of Cardiology [Electronic resource]. Режим доступа: https://www.acc.org/latest-in-cardiology/articles/2021/04/16/13/09/the-succour-trial. Дата обращения: 15.02.2022.

11. Laufer-Perl M., Gilon D., Kapusta L., et al. The role of speckle strain echocardiography in the diagnosis of early subclinical cardiac injury in cancer patients — is there more than just left ventricle global longitudinal strain? // J Clin Med. 2021. Vol. 10, № 1. P. 154. doi: 10.3390/JCM10010154

12. Laufer-Pearl M., Arnold J.H., Mor L., et al. The association of reduced global longitudinal strain with cancer therapy-related cardiac dysfunction among patients receiving cancer therapy // Clin Res Cardiol. 2020. Vol. 109, № 2. P. 255–262. doi: 10.1007/S00392-019-01508-9

13. Choi J.O., Shin D.H., Cho S.W., et al. Effect of preload on left ventricular longitudinal strain by 2D speckle tracking // Echocardiography. 2008. Vol. 25, № 8. P. 873–879. doi: 10.1111/j.1540-8175.2008.00707.x

14. Santoro C., Arpino G., Esposito R., et al. 2D and 3D strain for detection of subclinical anthracycline cardiotoxicity in breast cancer patients: a balance with feasibility // Eur Heart J Cardiovasc Imaging. 2017. Vol. 18, № 8. P. 930–936. doi: 10.1093/ehjci/jex033

15. Santoro C., Esposito R., Lembo M., et al. Strain-oriented strategy for guiding cardioprotection initiation of breast cancer patients experiencing cardiac dysfunction // Eur Heart J Cardiovasc Imaging. 2019. Vol. 20, № 12. P. 1345–1352. doi: 10.1093/ehjci/jez194

16. Thavendiranathan P., Negishi T., Somerset E., et al. Strain-guided management of potentially cardiotoxic cancer therapy // J Am Coll Cardiol. 2021. Vol. 77, № 4. P. 392–401. doi: 10.1016/j.jacc.2020.11.020

17. Dobson R., Ghosh A.K., Ky B., et al. BSE and BCOS guideline for transthoracic echocardiographic assessment of adult cancer patients receiving anthracyclines and/or trastuzumab // JACC CardioOncology. 2021. Vol. 3, № 1. P. 1–16. doi: 10.1016/J.JACCAO.2021.01.011

18. Kuznetsova T., Thijs L., Knez J., et al. Prognostic value of left ventricular diastolic dysfunction in a general population // J Am Hear Assoc Cardiovasc Cerebrovasc Dis. 2014. Vol. 3, № 3. P. e000789. doi: 10.1161/JAHA.114.000789

19. Nagiub M., Nixon J.V., Kontos M.C. Ability of nonstrain diastolic parameters to predict doxorubicin-induced cardiomyopathy: a systematic review with meta-analysis // Cardiol Rev. 2018. Vol. 26, № 1. P. 29–34. doi: 10.1097/CRD.0000000000000161

20. Upshaw J.N., Finkelman B., Hubbard R.A., et al. Comprehensive assessment of changes in left ventricular diastolic function with contemporary breast cancer therapy // JACC Cardiovasc. 2020. Vol. 13, № 1. P. 198–210. doi: 10.1016/J.JCMG.2019.07.018

21. Mincu R.I., Lampe L.F., Mahabadi A.A., et al. Left ventricular diastolic function following anthracycline-based chemotherapy in patients with breast cancer without previous cardiac disease — a meta-analysis // J Clin Med. 2021. Vol. 10, № 17. P. 3890. doi: 10.3390/JCM10173890

22. Rossi A., Temporelli P.L., Quintana M., et al. Independent relationship of left atrial size and mortality in patients with heart failure: an individual patient meta-analysis of longitudinal data (MeRGE Heart Failure) // Eur J Heart Fail. 2009. Vol. 11, № 10. P. 929–936. doi: 10.1093/EURJHF/HFP112

23. Benjamin B., D'Agostino R., Belanger A., et al. Left atrial size and the risk of stroke and death. The Framingham Heart Study // Circulation. 1995. Vol. 92, № 4. P. 835–841. doi: 10.1161/01.CIR.92.4.835

24. Thomas L., Marwick H.T., Popescu A.B., et al. Left atrial structure and function, and left ventricular diastolic dysfunction: JACC state of the art review // J Am Coll Cardiol. 2019. Vol. 73, № 15. P. 1961–1977. doi: 10.1016/J.JACC.2019.01.059

25. Сережина Е.К., Обрезан А.Г. Значимость эхокардиогарфической оценки деформации миокарда левого предсердия в ранней диагностике сердечной недостаточности с сохраненной фракцией выброса // Кардиология. 2021. Т. 61, № 8. С. 68–75. doi: 10.18087/cardio.2021.8.n1418

26. Kebed K.Y., Addetia K., Lang R.M. Importance of the left atrium: more than a bystander? // Heart Failure Clinics. 2019. Vol. 15, № 2. P. 191–204. doi: 10.1016/j.hfc.2018.12.001

27. Litwin S.E. Left atrial strain: a single parameter for assessing the dark side of the cardiac cycle? // JACC: Cardiovascular Imaging. 2020. Vol. 13, № 10. P. 2114–2116. doi: 10.1016/j.jcmg.2020.07.037

28. Алехин М.Н., Калинин А.О. Диастолическая функция левого желудочка: значение глобальной продольной деформации левого предсердия // Ультразвуковая и функциональная диагностика. 2020. № 3. P. 91–104. doi: 10.24835/1607-0771-2020-3-91-104
29. Szilveszter B., Nagy A.I., Vattay B., et al. Left ventricular and atrial strain imaging with cardiac computed tomography: validation against echocardiography // J Cardiovasc Comput Tomogr. 2020. Vol. 14, № 4. P. 363–369. doi: 10.1016/j.jcct.2019.12.004
30. Kim J., Yum B., Palumbo M.C., et al. Left atrial strain impairment precedes geometric remodeling as a marker of post-myocardial infarction diastolic dysfunction // JACC Cardiovasc. Imaging. 2020. Vol. 13, № 10. P. 2099–2113. doi: 10.1016/j.jcmg.2020.05.041
31. Pathan F., Zainal Abidin H.A., Vo Q.H., et al. Left atrial strain: a multi-modality, multi-vendor comparison study // Eur Heart J Cardiovasc. 2021. Vol. 22, № 1. P. 102–110. doi: 10.1093/ehjci/jez303
32. Genovese D., Singh A., Volpato V., et al. Load dependency of left atrial strain in normal subjects // J Am Soc Echocardiogr. 2018. Vol. 31, № 11. P. 1221–1228. doi: 10.1016/j.echo.2018.07.016
33. Brecht A., Oertelt-Prigione S., Seeland U., et al. Left atrial function in preclinical diastolic dysfunction: two-dimensional speckle-tracking echocardiography — derived results from the BEFRI Trial // J Am Soc Echocardiogr. 2016. Vol. 29, № 8. P. 750–758. doi: 10.1016/j.echo.2016.03.013
34. Lundberg A., Johnson J., Hage C., et al. Left atrial strain improves estimation of filling pressures in heart failure: a simultaneous echocardiographic and invasive haemodynamic study // Clin Res Cardiol. 2019. Vol. 108. P. 703–715. doi: 10.1007/s00392-018-1399-8
35. Mandoli G.E., Sisti N., Mondillo S., et al. Left atrial strain in left ventricular diastolic dysfunction: have we finally found the missing piece of the puzzle? // Heart Fail Rev. 2020. Vol. 25, № 3. P. 409–417. doi: 10.1007/s10741-019-09889-9
36. Pathan F., D'Elia N., Nolan M.T., et al. Normal ranges of left atrial strain by speckle-tracking echocardiography: a systematic review and meta-analysis // J Am Soc Echocardiogr. 2017. Vol. 30, № 1. P. 59–70.e8. doi: 10.1016/j.echo.2016.09.007
37. Monte I., Bottari V., Buccheri S., et al. Chemotherapy-induced cardiotoxicity: subclinical cardiac dysfunction evidence using speckle tracking echocardiography // J Cardiovasc Echogr. 2013. Vol. 23, № 1. P. 33–38. doi: 10.4103/2211-4122.117983
38. Sonaglioni A., Albini A., Fossile E., et al. Speckle-tracking echocardiography for cardioncological evaluation in bevacizumab-treated colorectal cancer patients // Cardiovasc Toxicol. 2020. Vol. 20, № 6. P. 581–592. doi: 10.1007/s12012-020-09583-5
39. Meloche J., Nolan M., Amir E., et al. Temporal changes in left atrial function in women with HER2+ breast cancer receivig sequential anthracyclines and trastuzumab therapy // J Am Coll Cardiol. 2018. Vol. 71, № 11. P. A1524. doi: 10.1016/s0735-1097(18)32065-5
40. Emerson P., Stefani L., Terluk A., et al. Left atrial strain analysis in breast cancer patients post anthracycline (AC) // Hear Lung Circ. 2021. Vol. 30. P. S196. doi: 10.1016/j.hlc.2021.06.225
41. Laufer-Perl M., Arias O., Dorfman S.S., et al. Left atrial strain changes in patients with breast cancer during anthracycline therapy // Int J Cardiol. 2021. Vol. 330. P. 238–244. doi: 10.1016/J.IJCARD.2021.02.013
42. Moustafa S., Murphy K., Nelluri B.K., et al. Temporal trends of cardiac chambers function with trastuzumab in human epidermal growth factor receptor ii-positive breast cancer patients // Echocardiography. 2016. Vol. 33, № 3. P. 406–415. doi: 10.1111/echo.13087
43. Moreno J., García-Sáez J.A., Clavero M., et al. Effect of breast cancer cardiotoxic drugs on left atrial myocardium mechanics. Searching for an early cardiotoxicity marker // Int J Cardiol. 2016. Vol. 210. P. 32–34. doi: 10.1016/j.ijcard.2016.02.093
44. Setti E., Dolci G., Bergamini C., et al. P2460 prospective evaluation of atrial function by 2D speckle tracking analysis in HER-2 positive breast cancer patients during Trastuzumab therapy // Eur Heart J. 2019. Vol. 40, Suppl. 1. P. 2460. doi: 10.1093/eurheartj/ehz748.0792
45. Moustafa S., Ho T.H., Shah P., et al. Predictors of incipient dysfunction of all cardiac chambers after treatment of metastatic renal cell carcinoma by tyrosine kinase inhibitors // J Clin Ultrasound. 2016. Vol. 44, № 4. P. 221. doi: 10.1002/JCU.22333
46. Anqi Y., Yu Z., Mingjun X., et al. Use of echocardiography to monitor myocardial damage during anthracycline chemotherapy // Echocardiography. 2019. Vol. 36, № 3. P. 495–502. doi: 10.1111/echo.14252
47. Timóteo A.T., Moura Branco L., Filipe F., et al. Cardiotoxicity in breast cancer treatment: what about left ventricular diastolic function and left atrial function? // Echocardiography. 2019. Vol. 36, № 10. P. 1806–1813. doi: 10.1111/echo.14487
48. Park H., Kim K.H., Kim H.Y., et al. Left atrial longitudinal strain as a predictor of cancer therapeutics-related cardiac dysfunction in patients with breast cancer // BioMed Central. 2020. Vol. 18, № 1. P. 1–8. doi: 10.1186/S12947-020-00210-5
49. Di Lisi D., Cadeddu Dessalvi C., Manno G., et al. Left atrial strain and left atrial stiffness for early detection of cardiotoxicity in cancer patients // Eur Heart J. 2021. Vol. 42, Suppl. 1. P. 2021. doi: 10.1093/eurheartj/ehab724.021
50. Li V.W., Lai C.T., Liu A.P, et al. Left atrial mechanics and integrated calibrated backscatter in anthracycline-treated long-term survivors of childhood cancers // Ultrasound Med Biol. 2017. Vol. 43, № 9. P. 1897–1905. doi: 10.1016/j.ultrasmedbio.2017.05.017
51. Loar R.W., Colquitt J.L., Rainusso N.C., et al. Assessing the left atrium of childhood cancer survivors // Int J Cardiovasc. 2021. Vol. 37, № 1. P. 155–162. doi: 10.1007/s10554-020-01970-x
52. Patel N.R., Chyu C.K., Satou G.M., et al. Left atrial function in children and young adult cancer survivors treated with anthracyclines // Echocardiography. 2018. Vol. 35, № 10. P. 1649–1656. doi: 10.1111/echo.14100
53. Tadic M., Genger M., Cuspidi C., et al. Phasic left atrial function in cancer patients before initiation of anti-cancer therapy // J Clin Med. 2019. Vol. 8. P. 421. doi: 10.3390/JCM8040421
54. Liao J.N., Chao T.F., Kuo J.Y., et al. Age, sex, and blood pressure-related influences on reference values of left atrial deformation and mechanics from a large-scale asian population // Circ Cardiovasc Imaging. 2017. Vol. 10, № 10. P. e006077. doi: 10.1161/CIRCIMAGING.116.006077
55. Cameli M., Mandoli G.E., Loiacono F., et al. Left atrial strain: a new parameter for assessment of left ventricular filling pressure // Heart Fail Rev. 2016. Vol. 21, № 1. P. 65–76. doi: 10.1007/S10741-015-9520-9
56. Singh A., El Hangouche N., McGee K., et al. Utilizing left atrial strain to identify patients at risk for atrial fibrillation on ibrutinib // Echocardiography. 2021. Vol. 38, № 1. P. 81–88. doi: 10.1111/echo.14946

REFERENCES

1. Herrmann J, Lerman A, Sandhu NP, et al. Evaluation and management of patients with heart disease and cancer: cardio-oncology. *Mayo Clin Proc*. 2014;89(9):1287. doi: 10.1016/J.MAYOCP.2014.05.013

2. Okwuosa TM, Anzevino S, Rao R. Cardiovascular disease in cancer survivors. *Postgrad Med J*. 2017;93(1096):82–90. doi: 10.1136/POSTGRADMEDJ-2016-134417

3. Fidler MM, Reulen RC, Henson K, et al. Population-based long-term cardiac-specific mortality among 34 489 five-year survivors of childhood cancer in Great Britain. *Circulation*. 2017;135(10):951–963. doi: 10.1161/CIRCULATIONAHA.116.024811

4. Miller KD, Nogueira L, Mariotto AB, et al. Cancer treatment and s urvivorship statistics, 2019. *CA Cancer J Clin*. 2019;69(5):363–385. doi: 10.3322/CAAC.21565

5. Valero-Elizondo J, Chouairi F, Khera R, et al. Atherosclerotic cardiovascular disease, cancer, and financial toxicity among adults in the United States. *JACC CardioOncology*. 2021;3(2):236–246. doi: 10.1016/J.JACCAO.2021.02.006

6. Tajiri K, Aonuma K, Sekine I. Cardio-oncology: a multidisciplinary approach for detection, prevention and management of cardiac dysfunction in cancer patients. *JJCO Japanese J Clin Oncol*. 2017;47(8):678–682. doi: 10.1093/jjco/hyx068

7. Chang HM, Moudgil R, Scarabelli T, et al. Cardiovascular complications of cancer therapy: best practices in diagnosis, prevention, and management: part 1. *J Am Coll Cardiol*. 2017;70(20):2536–2551. doi: 10.1016/j.jacc.2017.09.1096

8. Armstrong GT, Ross JD. Late cardiotoxicity in aging adult survivors of childhood cancer. *Prog Pediatr Cardiol*. 2014;36(1-2):19. doi: 10.1016/J.PPEDCARD.2014.09.003

9. Lati G, Heck SL, Ree AH, et al. Prevention of cardiac dysfunction during adjuvant breast cancer therapy (PRADA): a 2×2 factorial, randomized, placebo-controlled, double-blind clinical trial of candesartan and metoprolol. *Eur Heart J*. 2016;37(21):1671–1680. doi: 10.1093/eurheartj/ehw022

10. Lopez-Mattei JC, Hassan S. The SUCCOUR trial: a cardiovascular imager's perspective — American College of Cardiology [Electronic resource]. Available from: https://www.acc.org/latest-in-cardiology/articles/2021/04/16/13/09/the-succour-trial. Accessed: 15.02.2022.

11. Laufer-Perl M, Gilon D, Kapusta L, Iakobishvili Z. The role of speckle strain echocardiography in the diagnosis of early subclinical cardiac injury in cancer patients — is there more than just left ventricle global longitudinal strain? *J Clin Med.* 2021;10(1):154. doi: 10.3390/JCM10010154

12. Laufer-Pearl M, Arnold JH, Mor L, et al. The association of reduced global longitudinal strain with cancer therapy-related cardiac dysfunction among patients receiving cancer therapy. *Clin Res Cardiol*. 2020;109(2):255–262. doi: 10.1007/S00392-019-01508-9

13. Choi JO, Shin DH, Cho SW, et al. Effect of preload on left ventricular longitudinal strain by 2D speckle tracking. *Echocardiography*. 2008;25(8):873–879. doi: 10.1111/j.1540-8175.2008.00707.x

14. Santoro C, Arpino G, Esposito R, et al. 2D and 3D strain for detection of subclinical anthracycline cardiotoxicity in breast cancer patients: a balance with feasibility. *Eur Heart J Cardiovasc Imaging*. 2017;18(8):930–936. doi: 10.1093/ehjci/jex033

15. Santoro C, Esposito R, Lembo M, et al. Strain-oriented strategy for guiding cardioprotection initiation of breast cancer patients experiencing cardiac dysfunction. *Eur Heart J Cardiovasc Imaging*. 2019;20(12):1345–1352. doi: 10.1093/ehjci/jez194

16. Thavendiranathan P, Negishi T, Somerset E, et al. Strain-guided management of potentially cardiotoxic cancer therapy. *J Am Coll Cardiol*. 2021;77(4):392–401. doi: 10.1016/j.jacc.2020.11.020

17. Dobson R, Ghosh AK, Ky B, et al. BSE and BCOS guideline for transthoracic echocardiographic assessment of adult cancer patients receiving anthracyclines and/or trastuzumab. *JACC CardioOncology*. 2021;3(1):1–16. doi: 10.1016/J.JACCAO.2021.01.011

18. Kuznetsova T, Thijs L, Knez J, et al. Prognostic value of left ventricular diastolic dysfunction in a general population. *J Am Hear Assoc Cardiovasc Cerebrovasc Dis*. 2014;3(3):e000789. doi: 10.1161/JAHA.114.000789

19. Nagiub M, Nixon JV, Kontos MC. Ability of nonstrain diastolic parameters to predict doxorubicin-induced cardiomyopathy: a systematic review with meta-analysis. *Cardiol Rev*. 2018;26(1):29–34. doi: 10.1097/CRD.0000000000000161

20. Upshaw JN, Finkelman B, Hubbard RA, et al. Comprehensive assessment of changes in left ventricular diastolic function with contemporary breast cancer therapy. *JACC Cardiovasc Imaging*. 2020;13(1):198–210. doi: 10.1016/J.JCMG.2019.07.018

21. Mincu RI, Lampe LF, Mahabadi AA, et al. Left ventricular diastolic function following anthracycline-based chemotherapy in patients with breast cancer without previous cardiac disease — a meta-analysis. *J Clin Med*. 2021;10(17):3890. doi: 10.3390/JCM10173890

22. Rossi A, Temporelli PL, Quintana M, et al. Independent relationship of left atrial size and mortality in patients with heart failure: an individual patient meta-analysis of longitudinal data (MeRGE Heart Failure). *Eur J Heart Fail*. 2009;11(10):929–936. doi: 10.1093/EURJHF/HFP112

23. Benjamin E, D'Agostino R, Belanger A. Left atrial size and the risk of stroke and death. The Framingham Heart Study. *Circulation*. 1995;92(4):835–841. doi: 10.1161/01.CIR.92.4.835

24. Thomas L, Marwick HT, Popescu AB, et al. Left atrial structure and function, and left ventricular diastolic dysfunction: JACC state of the art review. *J Am Coll Cardiol*. 2019;73(15):1961–1977. doi: 10.1016/J.JACC.2019.01.059

25. Serezhina EK, Obrezan AG. Significance of the echocardiographic evaluation of left atrial myocardial strain for early diagnosis of heart failure with preserved ejection fraction. *Kardiologiia*. 2021;61(8):68–75. (In Russ). doi: 10.18087/cardio.2021.8.n1418

26. Kebed KY, Addetia K, Lang RM. Importance of the left atrium: more than a bystander? *Heart Fail Clin*. 2019;15(2):191–204. doi: 10.1016/j.hfc.2018.12.001

27. Litwin SE. Left atrial strain: a single parameter for assessing the dark side of the cardiac cycle? *JACC Cardiovasc Imaging*. 2020;13(10):2114–2116. doi: 10.1016/j.jcmg.2020.07.037

28. Alekhin MN, Kalinin AO. Diastolic function of the left ventricle: the meaning of left atrium longitudinal strain. *Ultrasound Funct Diagnostics*. 2020;(3):91–104. (In Russ). doi: 10.24835/1607-0771-2020-3-91-104

29. Szilveszter B, Nagy AI, Vattay B, et al. Left ventricular and atrial strain imaging with cardiac computed tomography: validation against echocardiography. *J Cardiovasc Comput Tomogr*. 2020;14(4):363–369. doi: 10.1016/j.jcct.2019.12.004

30. Kim J, Yum B, Palumbo MC, et al. Left atrial strain impairment precedes geometric remodeling as a marker of post-myocardial infarction diastolic dysfunction. *JACC Cardiovasc Imaging*. 2020;13(10):2099–2113. doi: 10.1016/j.jcmg.2020.05.041
31. Pathan F, Zainal Abidin HA, Vo QH, et al. Left atrial strain: a multi-modality, multi-vendor comparison study. *Eur Heart J Cardiovasc Imaging*. 2021;22(1):102–110. doi: 10.1093/ehjci/jez303
32. Genovese D, Singh A, Volpato V, et al. Load dependency of left atrial strain in normal subjects. *J Am Soc Echocardiogr*. 2018;31(11):1221–1228. doi: 10.1016/j.echo.2018.07.016
33. Brecht A, Oertelt-Prigione S, Seeland U, et al. Left Atrial function in preclinical diastolic dysfunction: two-dimensional speckle-tracking echocardiography — derived results from the BEFRI trial. *J Am Soc Echocardiogr*. 2016;29(8):750–758. doi: 10.1016/j.echo.2016.03.013
34. Lundberg A, Johnson J, Hage C, et al. Left atrial strain improves estimation of filling pressures in heart failure: a simultaneous echocardiographic and invasive haemodynamic study. *Clin Res Cardiol*. 2019;108:703–715. doi: 10.1007/s00392-018-1399-8
35. Mandoli GE, Sisti N, Mondillo S, et al. Left atrial strain in left ventricular diastolic dysfunction: have we finally found the missing piece of the puzzle? *Heart Fail Rev*. 2020;25(3):409–417. doi: 10.1007/s10741-019-09889-9
36. Pathan F, D'Elia N, Nolan MT, et al. Normal ranges of left atrial strain by speckle-tracking echocardiography: a systematic review and meta-analysis. *J Am Soc Echocardiogr*. 2017;30(1):59–70.e8. doi: 10.1016/j.echo.2016.09.007
37. Monte I, Bottari V, Buccheri S, et al. Chemotherapy-induced cardiotoxicity: subclinical cardiac dysfunction evidence using speckle tracking echocardiography. *J Cardiovasc Echogr*. 2013;23(1):33–38. doi: 10.4103/2211-4122.117983
38. Sonaglioni A, Albini A, Fossile E, et al. Speckle-tracking echocardiography for cardioncological evaluation in bevacizumab-treated colorectal cancer patients. *Cardiovasc Toxicol*. 2020;20(6):581–592. doi: 10.1007/s12012-020-09583-5
39. Meloche J, Nolan M, Amir E, et al. Temporal changes in left atrial function in women with HER2+ breast cancer receivig sequential anthracyclines and trastuzumab therapy. *J Am Coll Cardiol*. 2018;71(11):A1524. doi: 10.1016/s0735-1097(18)32065-5
40. Emerson P, Stefani L, Terluk A, et al. Left atrial strain analysis in breast cancer patients post anthracycline (AC). *Hear Lung Circ*. 2021;30:S196. doi: 10.1016/j.hlc.2021.06.225
41. Laufer-Perl M, Arias O, Dorfman SS, et al. Left atrial strain changes in patients with breast cancer during anthracycline therapy. *Int J Cardiol*. 2021;330:238–244. doi: 10.1016/J.IJCARD.2021.02.013
42. Moustafa S, Murphy K, Nelluri BK, et al. Temporal trends of cardiac chambers function with trastuzumab in human epidermal growth factor receptor ii-positive breast cancer patients. *Echocardiography*. 2016;33(3):406–415. doi: 10.1111/echo.13087
43. Moreno J, García-Sáez JA, Clavero M, et al. Effect of breast cancer cardiotoxic drugs on left atrial myocardium mechanics. Searching for an early cardiotoxicity marker. *Int J Cardiol*. 2016;210:32–34. doi: 10.1016/j.ijcard.2016.02.093
44. Setti E, Dolci G, Bergamini C, et al. P2460 prospective evaluation of atrial function by 2D speckle tracking analysis in HER-2 positive breast cancer patients during Trastuzumab therapy. *Eur Heart J*. 2019;40(Suppl 1):2460. doi: 10.1093/eurheartj/ehz748.0792
45. Moustafa S, Ho TH, Shah P, et al. Predictors of Incipient dysfunction of all cardiac chambers after treatment of metastatic renal cell carcinoma by tyrosine kinase inhibitors. *J Clin Ultrasound*. 2016;44(4):221. doi: 10.1002/JCU.22333
46. Anqi Y, Yu Z, Mingjun X, et al. Use of echocardiography to monitor myocardial damage during anthracycline chemotherapy. *Echocardiography*. 2019;36(3):495–502. doi: 10.1111/echo.14252
47. Timóteo AT, Moura Branco L, Filipe F, et al. Cardiotoxicity in breast cancer treatment: What about left ventricular diastolic function and left atrial function? *Echocardiography*. 2019;36(10):1806–1813. doi: 10.1111/echo.14487
48. Park H, Kim KH, Kim HY, et al. Left atrial longitudinal strain as a predictor of cancer therapeutics-related cardiac dysfunction in patients with breast cancer. *Cardiovasc Ultrasound*. 2020;18(1):1–8. doi: 10.1186/S12947-020-00210-5
49. Di Lisi D, Cadeddu Dessalvi C, Manno G, et al. Left atrial strain and left atrial stiffness for early detection of cardiotoxicity in cancer patients. *Eur Heart J*. 2021;42(Suppl 1):2021. doi: 10.1093/eurheartj/ehab724.021
50. Li VW, Lai CT, Liu AP, et al. Left atrial mechanics and integrated calibrated backscatter in anthracycline-treated long-term survivors of childhood cancers. *Ultrasound Med Biol*. 2017;43(9):1897–1905. doi: 10.1016/j.ultrasmedbio.2017.05.017
51. Loar RW, Colquitt JL, Rainusso NC, et al. Assessing the left atrium of childhood cancer survivors. *Int J Cardiovasc Imaging*. 2021;37(1):155–162. doi: 10.1007/s10554-020-01970-x
52. Patel NR, Chyu CK, Satou GM, et al. Left atrial function in children and young adult cancer survivors treated with anthracyclines. *Echocardiography*. 2018;35(10):1649–1656. doi: 10.1111/echo.14100
53. Tadic M, Genger M, Cuspidi C, et al. Phasic left atrial function in cancer patients before initiation of anti-cancer therapy. *J Clin Med*. 2019;8(4):421. doi: 10.3390/JCM8040421
54. Liao JN, Chao TF, Kuo JY, et al. Age, sex, and blood pressure-related influences on reference values of left atrial deformation and mechanics from a large-scale asian population. *Circ Cardiovasc Imaging*. 2017;10(10):e006077. doi: 10.1161/CIRCIMAGING.116.006077
55. Cameli M, Mandoli GE, Loiacono F, et al. Left atrial strain: a new parameter for assessment of left ventricular filling pressure. *Heart Fail Rev*. 2016;21(1):65–76. doi: 10.1007/S10741-015-9520-9
56. Singh A, El Hangouche N, McGee K, et al. Utilizing left atrial strain to identify patients at risk for atrial fibrillation on ibrutinib. *Echocardiography*. 2021;38(1):81–88. doi: 10.1111/echo.14946

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