



Correlation between Peak Left Atrial Longitudinal Strain and The Severity of Mitral Valve Disease

¹ S.Darcy, ² M.Deen

^{1,2} Sidney Kimmel Medical College at Thomas Jefferson University, United States of America

Correspondence : darcymd3884@gmail.com

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ABSTRACT

Introduction

Peak left atrial longitudinal strain (PALS), a measure of left atrial (LA) mechanics, is an emerging tool for assessing the severity of mitral valve disease. Changes in LA function often precede those in the left ventricle, positioning LA strain as a potential early marker for disease-related complications. This review synthesizes literature on the correlation between PALS and the severity of mitral valve disease, highlighting the evolving role of advanced echocardiographic techniques.

Methods

This abstract is based on a literature review synthesizing findings from multiple clinical studies and comprehensive reviews. The analysis examined the correlation between LA strain, measured by speckle-tracking echocardiography, and the severity of mitral valve disease. The review evaluated LA strain's relationship with LA fibrosis, diastolic function, clinical outcomes, and its prognostic value following surgical interventions.

Results

The literature demonstrates a strong correlation between reduced LA global strain and the extent of LA fibrosis in patients with mitral valve disease. PALS decreases as the severity of mitral stenosis

(MS) increases, serving as a predictor for atrial fibrillation and adverse cardiovascular outcomes. In mitral regurgitation (MR), impaired LA reservoir strain is associated with poorer survival rates after surgery and can predict the need for earlier intervention. Furthermore, left ventricular longitudinal strain, which is closely related to atrial function, is a powerful predictor of all-cause mortality after heart valve surgery, often outperforming traditional measures like LVEF.

Discussion

The evidence confirms that PALS is a valuable and sensitive biomarker that reflects the structural and functional consequences of mitral valve disease. It provides a more accurate assessment of myocardial health than traditional metrics, particularly in chronic MR where LVEF can be misleading. The link between impaired strain and underlying fibrosis provides a pathophysiological basis for its prognostic power. The ability of LA strain to predict adverse outcomes underscores its potential to refine clinical decision-making and guide timing for surgical interventions.

Conclusion

Peak left atrial longitudinal strain is a critical tool for assessing the severity of mitral valve disease. Its strong correlation with LA fibrosis, clinical symptoms, and adverse outcomes supports its integration into routine cardiovascular assessment. Utilizing LA strain can enhance early detection, improve risk stratification, and ultimately optimize patient management and outcomes.

Keywords Peak Left Atrial Longitudinal Strain (PALS), Mitral Valve Disease, Left Atrial Strain, Speckle-Tracking Echocardiography, Mitral Regurgitation, Mitral Stenosis.

INTRODUCTION

The literature surrounding the correlation between peak left atrial longitudinal strain (PALS) and the severity of mitral valve disease has evolved significantly over the past decade. The initial exploration by (et al., 2002) established a foundational understanding, demonstrating that left atrial (LA) global strain measured through speckle tracking echocardiography is reproducible and significantly correlates with the degree of LA fibrosis in mitral valve disease patients. This study highlighted that LA compliance, akin to diastolic stiffness in the left ventricle (LV), is influenced by interstitial fibrosis, thus providing a crucial index for assessing LA reservoir function.

Building on this understanding, (Mahfouz Badran et al., 2003) investigated changes in LA deformation in hypertrophic cardiomyopathy, revealing that LA strain is significantly related to both LA volume index and LV systolic deformation. Their findings indicated that chronic mitral regurgitation (MR) exacerbates LA remodeling and diminishes elastic properties, further implicating the importance of LA strain in understanding the functional deterioration associated with mitral valve diseases.

(Król et al., 2006) expanded the discussion by assessing the linear correlation between LA strain and various diastolic function parameters, although they found no significant correlation with exercise capacity or LA morphology. This suggests that while LA strain is a pertinent measure, its relationship with functional parameters may not be as straightforward as previously thought.

focused specifically on mitral stenosis (MS), elucidating the acute effects of treatment on LA function. They posited that PALS serves as a predictor for atrial fibrillation and cardiovascular outcomes, emphasizing that LA strain diminishes with increasing severity of MS, thereby linking LA dysfunction directly to hemodynamic changes.

(Ring et al., 2008) further contributed to this discourse by examining the prognostic value of LA deformation in patients with severe MR. Their findings suggest that impaired atrial strain can predict adverse outcomes, reinforcing the notion that both

active and passive aspects of LA function are critical in the heart's adaptation to chronic MR.

In 2001, (Mehta et al., 2001) delved into the specific context of severe rheumatic mitral stenosis and pulmonary hypertension, employing two-dimensional speckle tracking echocardiography to quantify LA function. Their research underscored the correlation between LA dysfunction and clinical parameters, reinforcing the utility of LA strain in evaluating patients with severe MS.

(Nam et al., 2002) shifted focus to the prognostic implications of left ventricular longitudinal strain post-heart valve surgery, asserting its predictive power for all-cause mortality. Their work highlights the limitations of traditional measures like left ventricular ejection fraction (LVEF) in patients with significant MR, thereby advocating for the integration of LA strain assessment in clinical practice.

The investigation into the long-term prognostic value of LA longitudinal strain in an elderly cohort by (Zhubi Bakija et al., 2002) further emphasizes the importance of LA mechanics in predicting adverse outcomes in heart failure, suggesting that LA strain can serve as a sensitive biomarker for long-term prognosis.

Finally, (O'Neill et al., 2004) provided a comprehensive review of the clinical applications of LA strain, positing that LA strain imaging is a promising tool for diagnosing and prognosticating cardiovascular pathologies. Their insights reaffirm the notion that changes in LA function often precede those in the LV, underscoring the critical role of LA strain in the early detection of mitral valve disease-related complications.

This literature review synthesizes these findings, contributing to a nuanced understanding of the relationship between peak left atrial longitudinal strain and the severity of mitral valve disease, while highlighting the evolving role of echocardiographic techniques in cardiac assessment.

LITERATURE REVIEW

The article titled "Prediction of left atrial fibrosis with speckle tracking echocardiography in mitral valve disease: a comparative study with histopathology" by (et al., 2002) provides valuable insights into the relationship between left atrial (LA) strain and the severity of mitral valve (MV) disease. The authors conducted a

comparative study that aimed to investigate the correlation between LA global strain, measured through speckle tracking echocardiography, and the degree of LA fibrosis as determined by histopathological examination.

A significant finding of this study is the strong correlation between LA global strain and the extent of LA fibrosis in patients suffering from MV disease. The authors emphasize that LA global strain can serve as an important index for assessing LA compliance and reservoir function, which are critical in understanding the hemodynamics associated with conditions such as mitral stenosis (MS) or mitral regurgitation (MR) and various cardiomyopathies. This correlation suggests that impaired LA function, as indicated by reduced global strain, may reflect underlying structural changes such as fibrosis.

Moreover, the study highlights the specific relationship between peak longitudinal strain during ventricular systole and the degree of LA interstitial fibrosis. The findings indicate that as the severity of fibrosis increases, there is a corresponding decline in LA peak lengthening strain, thereby reinforcing the notion that LA strain measurements can provide valuable prognostic information in the context of MV disease.

The authors also note the clinical implications of their findings, suggesting that LA global strain and early strain rate could be utilized as non-invasive markers for evaluating LA function in patients with MV disease. This could potentially guide clinical decision-making and management strategies for patients with abnormal LA function, thereby enhancing patient outcomes.

The article "Changes in left atrial deformation in hypertrophic cardiomyopathy: Evaluation by vector velocity imaging" by (Mahfouz Badran et al., 2003) provides significant insights into the relationship between left atrial (LA) deformation and the severity of mitral valve disease, particularly in the context of hypertrophic cardiomyopathy (HCM). The authors emphasize that left atrial peak lengthening during ventricular systole, as indicated by positive strain and strain rate (SR), serves as critical markers for LA compliance. This is particularly relevant in understanding LA function in patients with mitral regurgitation (MR), a common manifestation of mitral valve disease.

The study establishes a correlation between LA reservoir function and LA deformation metrics, specifically LA early systolic strain (esys). The findings indicate that LA esys is significantly correlated with LA SR sys, suggesting that these measures can serve as valuable indices of LA reservoir function. This is important, as the authors note that quantification of longitudinal myocardial LA deformation reveals a significant reduction in patients with HCM, which correlates strongly with LA volume index and left ventricular (LV) mass index, as well as LV systolic deformation as measured by global LV esys and SR.

One of the pivotal insights from the article is the inverse relationship between LA reservoir function and the severity of mitral regurgitation. Chronic MR leads to volume overload, LA remodeling, and a deterioration in LA elastic properties, resulting in increased LA pressure. This pathological progression exacerbates the impairment of LA reservoir function in patients with HCM, as evidenced by the study's finding that 98% of participants exhibited mild to severe MR. Furthermore, the authors report that LA esys decreases linearly with increasing severity of LV diastolic dysfunction, highlighting the interplay between LA mechanics and LV function.

In critically evaluating the material, it is clear that the authors provide a robust framework for understanding the implications of LA deformation in the context of mitral valve disease. The use of vector velocity imaging to assess LA strain offers a novel approach that enhances the ability to quantify changes in LA function. However, the study's focus is primarily on patients with HCM, which may limit the generalizability of the findings to other populations with varying forms of mitral valve disease. Future research could expand on these findings by exploring the relationship between LA deformation and mitral valve disease severity across a broader patient demographic, as well as investigating potential therapeutic interventions aimed at improving LA function in these patients.

The article "Left Atrial Enlargement in Young High-Level Endurance Athletes – Another Sign of Athlete's Heart?" by (Król et al., 2006) investigates the relationship between left atrial (LA) strain and various cardiac parameters in a cohort of young endurance athletes. The study's main focus is to assess the linear correlation

between LA strain and diastolic function, left ventricular (LV) size and hypertrophy, exercise capacity, and LA size.

The authors conducted a thorough analysis, measuring LA strain and correlating it with diastolic function and morphological characteristics of the heart. However, the findings revealed no significant correlation between LA functional parameters and the morphology of the LV and LA. This lack of correlation raises important questions about the utility of LA strain as a clinical marker in this specific population. Furthermore, the absence of significant associations between LA strain and exercise capacity suggests that traditional metrics of cardiac performance may not fully capture the adaptations seen in high-level athletes.

The study's methodology is commendable, as it utilizes a well-defined cohort of young athletes, which allows for a focused examination of the athlete's heart phenomenon. However, the implications of the findings may limit the applicability of LA strain as a standalone indicator of cardiac health in athletes. The results suggest that while LA enlargement is common in endurance athletes, it does not necessarily correlate with functional performance or diastolic dysfunction, which is often a concern in the context of mitral valve disease.

The article "Acute Effect of Treatment of Mitral Stenosis on Left Atrium Function" by provides critical insights into the relationship between mitral stenosis (MS) and left atrial (LA) function, specifically through the lens of peak atrial longitudinal strain (PALS). The authors articulate that MS, primarily resulting from rheumatic fever, leads to significant LA dilation and fibrosis, which are pivotal in understanding the functional impairment of the atrium.

One of the key findings presented in the article is the correlation between the severity of mitral stenosis and the reduction of strain in the left atrium. The authors emphasize that during left ventricular systole, the left atrium undergoes enlargement, which is quantitatively assessed through PALS. This positive strain measurement serves as an important diagnostic tool, indicating not only the mechanical function of the LA but also its potential predictive value for atrial fibrillation (AF) and broader cardiovascular outcomes.

The methodology employed in the study, including the use of two-dimensional speckle tracking echocardiography (2D STE) for quantifying LA strain, is particularly noteworthy. This approach allows for a nuanced understanding of LA function, enabling clinicians to evaluate the hemodynamic severity of MS more accurately. The findings suggest that patients with severe MS exhibit significantly reduced strain, highlighting the potential of PALS as a marker for assessing the impact of MS on LA function.

Moreover, the article discusses the implications of mitral regurgitation on LA function, noting that it exerts a negative influence. This aspect broadens the scope of understanding LA dynamics in the context of valvular heart disease, reinforcing the need for comprehensive evaluations in patients presenting with various forms of mitral valve pathology.

The article titled "Left atrial function is associated with earlier need for cardiac surgery in moderate to severe mitral regurgitation: Usefulness in targeting for early surgery" by (Ring et al., 2008) provides significant insights into the prognostic implications of left atrial (LA) deformation, particularly in the context of mitral valve disease. The authors emphasize the importance of assessing LA strain, particularly reservoir strain, as a predictive marker for the progression of mitral regurgitation (MR) and the subsequent need for surgical intervention.

A key finding of the study is that impaired atrial strain, specifically a reservoir strain of less than 24%, has been associated with poorer survival rates following mitral valve surgery ((Ring et al., 2008)). This underscores the critical role that both active and passive aspects of LA function play in the heart's adaptation to chronic MR. The authors argue that reservoir strain serves as an indicator of the LA's ability to accommodate the regurgitant jet and adapt to increased filling pressures, which is essential for maintaining cardiac efficiency and preventing heart failure symptoms. The article further critiques conventional guidelines for surgical intervention in patients with mitral valve prolapse (MVP) and associated MR, which primarily rely on the emergence of cardiovascular symptoms, elevated pulmonary pressures, or left ventricular dysfunction. The authors point out that by the time these criteria are met, patient outcomes tend to be suboptimal, suggesting a need for earlier

intervention strategies. They advocate for the incorporation of atrial strain assessment as a tool to identify patients who may benefit from earlier surgical referral or intensified clinical monitoring before the onset of more severe symptoms ((Ring et al., 2008)).

Despite the compelling findings, the authors acknowledge certain limitations inherent in their study, particularly the retrospective nature and single-center design, which could introduce referral bias. They call for further validation of their results through prospective trials across multiple centers to enhance the generalizability of their conclusions.

The article titled "Left atrial function by two-dimensional speckle tracking echocardiography in patients with severe rheumatic mitral stenosis and pulmonary hypertension" by (Mehta et al., 2001) provides a comprehensive analysis of left atrial (LA) function in the context of severe rheumatic mitral stenosis (MS) and its associated pulmonary hypertension. The authors emphasize the significance of LA dysfunction as a critical component in the pathophysiology of chronic rheumatic heart disease (RHD), highlighting the direct consequences of mitral stenosis on LA mechanics.

The study effectively utilizes two-dimensional speckle tracking echocardiography (STE) to quantify various aspects of LA function, specifically focusing on reservoir, conduit, and contractile strains. This methodological approach is particularly noteworthy, as it allows for a nuanced understanding of LA deformation and its correlation with clinical parameters, such as the New York Heart Association (NYHA) functional class. The findings reveal that LA dysfunction, characterized by impaired strain parameters, is prevalent in patients with severe MS and correlates significantly with the severity of symptoms and echocardiographic findings.

One of the key insights from the article is the relationship between chronic LA pressure overload due to mitral stenosis and the resultant atrial muscle disorganization and fibrosis. This pathological progression leads to increased atrial stiffness and a decline in reservoir function, ultimately contributing to the development of post-capillary pulmonary hypertension. The authors present a compelling argument that the assessment of LA function through STE can serve as

a valuable tool in evaluating the severity of mitral valve disease and its systemic implications.

However, while the study presents robust data correlating LA function with clinical parameters, it is essential to consider the limitations inherent in the study design. The authors primarily focus on a specific patient cohort with isolated severe MS and pulmonary hypertension, which may limit the generalizability of the findings to broader populations, including those with mixed valve disease or different etiologies of mitral stenosis. Additionally, the cross-sectional nature of the study restricts the ability to draw conclusions about causality or the temporal relationship between LA dysfunction and disease progression.

The article titled "Prognostic value of left ventricular apical four-chamber longitudinal strain after heart valve surgery in real-world practice" by (Nam et al., 2002) presents a comprehensive analysis of the prognostic implications of left ventricular longitudinal strain (LVLS) in the context of heart valve surgery. The study's observational design included a substantial cohort of 1,773 patients, which enhances the reliability of its findings regarding the relationship between LVLS and postoperative outcomes.

The authors highlight that LVLS is significantly associated with all-cause mortality following heart valve surgery, suggesting that it may serve as a valuable prognostic tool beyond traditional measures such as left ventricular ejection fraction (LVEF). This is particularly relevant in cases of significant mitral regurgitation (MR), where LVEF can be misleading due to the overestimation caused by the regurgitant fraction. The study effectively illustrates that LVLS provides a more accurate reflection of myocardial function, as it is less affected by loading conditions compared to LVEF. This distinction is crucial, as it implies that patients may have compromised myocardial performance that is not evident when relying solely on LVEF.

Furthermore, the authors present compelling evidence that the correlation between preoperative LVLS and immediate postoperative LVEF is stronger than that of preoperative LVEF with postoperative LVEF. This finding underscores the potential of LVLS as an early indicator of myocardial health, particularly in the

setting of valvular heart disease. The article also emphasizes the vulnerability of longitudinal myocardial fibers, which are predominantly found in the subendocardial layer, to injury in the early stages of valve disease. This anatomical consideration provides a biological basis for the observed deterioration in LVLS prior to any significant changes in LVEF.

The study's conclusions extend beyond the realm of MR, indicating that the relationship between LVLS and long-term mortality is not confined to patients with this specific condition. This broad applicability enhances the clinical relevance of the findings, suggesting that LVLS could be a useful parameter for assessing cardiac function in a variety of settings involving valvular pathology.

The article "Long-term prognostic value of left atrial longitudinal strain in an elderly community-based cohort" by (Zhubi Bakija et al., 2002) provides a comprehensive examination of the prognostic significance of left atrial longitudinal strain (LA strain) in the context of heart failure (HF) and its relationship with mitral valve disease. The authors emphasize the utility of echocardiographic techniques, particularly speckle tracking echocardiography (STE), in assessing cardiac function and structural abnormalities. One of the key insights from this study is the ability of LA strain to serve as an early marker of cardiac dysfunction, particularly in the elderly population. The authors argue that traditional measures of left ventricular (LV) function may not adequately capture early diastolic dysfunction, which often precedes systolic dysfunction. This is particularly relevant in the context of mitral valve disease, where diastolic dysfunction can significantly impact left atrial function and strain. The study highlights that reduced LA strain correlates with the severity of underlying cardiac conditions, including mitral valve disease, suggesting its potential as a sensitive biomarker for assessing disease progression.

The article also discusses the implications of LA strain in predicting adverse clinical outcomes, including the risk of atrial fibrillation and embolic events. The authors provide evidence that LA strain deteriorates progressively with the severity of underlying cardiac diseases, reinforcing the notion that monitoring LA function could enhance risk stratification in patients with mitral valve disease. This is

particularly pertinent given the high prevalence of HF and associated morbidity in the elderly population.

However, while the study presents compelling data regarding the prognostic value of LA strain, it is essential to consider the limitations inherent in community-based cohorts. The generalizability of the findings may be affected by factors such as selection bias and the variability in disease severity among participants. Additionally, the authors acknowledge that further research is warranted to establish standardized thresholds for LA strain measurements and their clinical applicability in diverse populations.

The article titled "The Clinical Applications of Left Atrial Strain: A Comprehensive Review" by (O'Neill et al., 2004) provides a thorough examination of left atrial (LA) strain imaging, emphasizing its diagnostic and prognostic value in cardiovascular diseases. The authors highlight that LA strain (LAS) imaging, particularly through speckle-tracking echocardiography (STE), serves as a significant tool in assessing the deformation of the left atrium, which can reveal underlying pathologies before conventional echocardiographic parameters do.

A critical evaluation of the material reveals that the authors effectively categorize LA strain into three distinct phases: reservoir strain, conduit strain, and booster strain. This classification not only aids in understanding the mechanics of the left atrium during different phases of the cardiac cycle but also underscores the clinical relevance of each phase in relation to left ventricular (LV) pathophysiology. The notion that functional changes in the LA can serve as precursors to LV changes is particularly noteworthy, as it positions LAS as a potentially earlier marker for diagnosing mitral valve disease severity.

Moreover, the authors discuss the implications of LAS in various cardiovascular pathologies, suggesting that its assessment could enhance the prognostic capabilities of clinicians. The review synthesizes current evidence, presenting a compelling argument for the integration of LAS into routine clinical practice, particularly for patients with mitral valve disease. The authors also allude to future applications of LAS, indicating a growing recognition of its importance in cardiovascular diagnostics.

CONCLUSION

The literature on the correlation between peak left atrial longitudinal strain (PALS) and the severity of mitral valve disease reveals a nuanced interplay between atrial mechanics and valvular pathology. Initial studies have established that LA strain, measured through speckle tracking echocardiography, serves as a reliable indicator of left atrial (LA) function and correlates significantly with the degree of LA fibrosis in patients with mitral valve disease (et al., 2002). This foundational understanding is critical, as it links LA strain to underlying structural changes, particularly in the context of mitral regurgitation (MR) and mitral stenosis (MS). Subsequent research has expanded this understanding by exploring the effects of chronic conditions on LA deformation. For instance, studies have shown that chronic MR leads to LA remodeling and decreased elastic properties, which in turn affect LA strain metrics (Mahfouz Badran et al., 2003). The correlation between LA strain and diastolic function parameters, although not universally significant, suggests that LA strain may still hold value in assessing cardiac function in specific populations (Król et al., 2006).

Particularly noteworthy is the finding that PALS can serve as a predictor for atrial fibrillation and cardiovascular outcomes, especially in patients with MS . This predictive capability emphasizes the clinical relevance of LA strain measurements in managing patients with severe mitral valve disease. Moreover, studies indicate that impaired LA strain can forecast adverse outcomes in the context of MR, reinforcing the importance of LA function in clinical decision-making (Ring et al., 2008).

Recent investigations have further highlighted the prognostic value of LA strain in various clinical scenarios, including severe rheumatic MS and heart failure, suggesting that LA strain may serve as a sensitive biomarker for disease progression and long-term prognosis [ref: e665814d-0622-4e2f-80b2-381ceb899e07; ref: d58e5520-c801-45e8-b97b-0a27d130d76c]. Additionally, the integration of LA strain assessments into routine clinical practice has the potential to enhance early detection and management of mitral valve disease complications (O'Neill et al., 2004).

In conclusion, the body of literature underscores the critical role of peak left atrial longitudinal strain as a valuable tool for assessing the severity of mitral valve disease. The correlation between LA strain and various clinical parameters not only elucidates the pathophysiological mechanisms underlying mitral valve conditions but also supports the integration of echocardiographic techniques in routine cardiovascular assessment to improve patient outcomes.

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