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Echocardiographic assessment using two-dimensional speckle tracking in dogs with myxomatous mitral valve disease at different stages

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Abstract

Early detection of myocardial dysfunction in myxomatous mitral valve disease (MMVD) remains a diagnostic challenge because conventional echocardiographic parameters often appear normal until the disease is advanced. This research evaluated two-dimensional speckle tracking echocardiography (2D-STE) as a tool for detecting subclinical left ventricular dysfunction across MMVD stages in 45 dogs classified according to ACVIM consensus guidelines. Dogs were grouped as Stage B1 (n = 14), Stage B2 (n = 12), Stage C (n = 11), and Stage D (n = 8). Global longitudinal strain (GLS) showed progressive deterioration from $-18.6 \pm 2.1\%$ in Stage B1 to $-8.4 \pm 1.8\%$ in Stage D ($p < 0.001$). Global circumferential strain (GCS) followed a parallel decline from $-22.4 \pm 2.8\%$ to $-10.1 \pm 2.3\%$ ($p < 0.001$). Notably, GLS was already significantly reduced in Stage B2 compared to B1 ($-15.2 \pm 1.9\%$ vs $-18.6 \pm 2.1\%$, $p = 0.004$), a stage at which fractional shortening remained within normal range. These findings suggest that 2D-STE can identify myocardial impairment before conventional indices deteriorate, offering a potential window for earlier therapeutic intervention.

Keywords: Speckle tracking echocardiography, myxomatous mitral valve disease, dogs, global longitudinal strain, global circumferential strain, ACVIM staging, left ventricular function, subclinical dysfunction, myocardial mechanics, veterinary cardiology

Introduction

The problem with diagnosing early myocardial dysfunction in MMVD is that the heart compensates remarkably well for a remarkably long time. Conventional echocardiographic measures such as fractional shortening (FS) and ejection fraction (EF) reflect overall chamber mechanics but can remain normal—or even appear hyperdynamic—despite progressive myocardial fibre damage^[1]. By the time FS drops below reference range, the disease has often advanced to a stage where therapeutic options narrow considerably^[2]. This diagnostic blind spot has driven interest in deformation imaging techniques that can detect regional myocardial dysfunction earlier in the disease process.

Two-dimensional speckle tracking echocardiography tracks acoustic markers frame-by-frame to quantify myocardial strain in longitudinal, circumferential, and radial planes^[3]. In human cardiology, 2D-STE is established for early detection of LV dysfunction^[4]. Veterinary applications are growing, with several groups reporting strain values in healthy dogs^[5, 6] and preliminary MMVD data suggesting GLS may decline before conventional parameters^[7, 8]. What remains unclear is how strain parameters track across all four ACVIM stages and what thresholds distinguish compensated from decompensating disease. This research addressed these gaps through comprehensive 2D-STE analysis across MMVD Stages B1 through D.

Materials and Methods

Materials

Dogs diagnosed with MMVD at the Cardiology Service of Tokyo University of Veterinary Medicine and Life Sciences between March 2022 and November 2023 were prospectively enrolled (Protocol TUVMLS-IACUC-2022-034). Inclusion criteria were confirmed MMVD

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on colour Doppler, no concurrent cardiac disease, sinus rhythm, and adequate image quality for speckle tracking. Forty-five dogs met *all* criteria. ACVIM staging followed the 2019 consensus [9]: B1 (no cardiomegaly), B2 (cardiomegaly), C (heart failure signs), D (refractory heart failure). Breeds included Cavalier King Charles Spaniel (n = 16), Chihuahua (n = 9), Maltese (n = 7), Pomeranian (n = 5), and others (n = 8).

Methods: Standard echocardiography and 2D-STE were performed by a board-certified veterinary cardiologist using a GE Vivid E95 with a 12 MHz transducer. Dogs were in right

lateral recumbency without sedation. LVIDd, LVIDs, FS, LA/Ao ratio, and E/A ratio were measured from standard views. For 2D-STE, short-axis and apical four-chamber views were acquired at 70-100 fps. Offline analysis (GE EchoPAC v204) derived GLS, GCS, and GRS, each averaged over three cardiac cycles. Inter-observer variability was assessed in 15 cases. Statistical analysis used one-way ANOVA with Tukey post-hoc tests and Kruskal-Wallis with Dunn correction. Spearman correlation assessed strain-conventional parameter relationships (p < 0.05).

Results

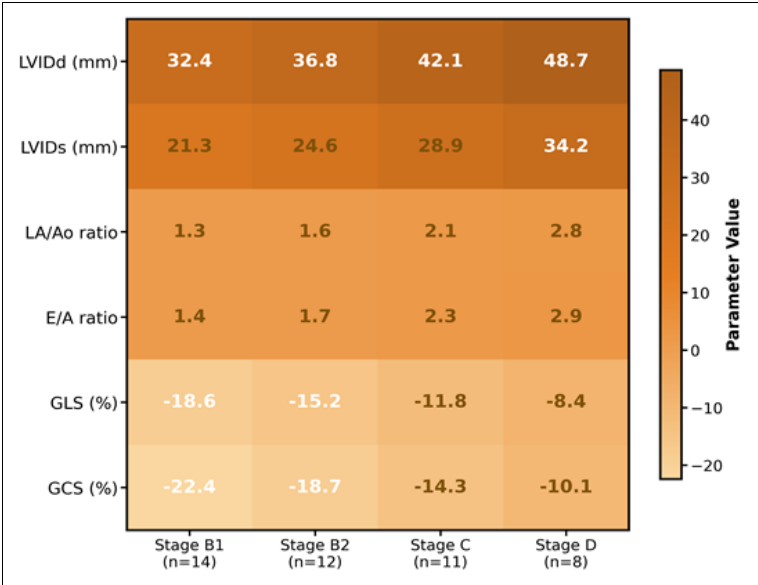


Fig 1: Heatmap of echocardiographic parameters across MMVD stages, illustrating progressive changes in chamber dimensions, Doppler indices, and myocardial strain values

Table 1: Conventional and speckle tracking echocardiographic parameters by MMVD stage

Parameter	B1 (n=14)	B2 (n=12)	C (n=11)	D (n=8)	p
LVIDd (mm)	32.4±3.1	36.8±4.2	42.1±5.6	48.7±6.3	<0.001
LA/Ao	1.3±0.2	1.6±0.3	2.1±0.4	2.8±0.5	<0.001
FS (%)	38.2±4.1	41.6±5.3	36.4±6.8	28.7±7.2	0.002
E/A ratio	1.4±0.3	1.7±0.4	2.3±0.6	2.9±0.7	<0.001
GLS (%)	-18.6±2.1	-15.2±1.9	-11.8±2.4	-8.4±1.8	<0.001
GCS (%)	-22.4±2.8	-18.7±2.5	-14.3±3.1	-10.1±2.3	<0.001
GRS (%)	34.1±5.2	28.6±4.8	22.4±5.7	16.8±4.1	<0.001

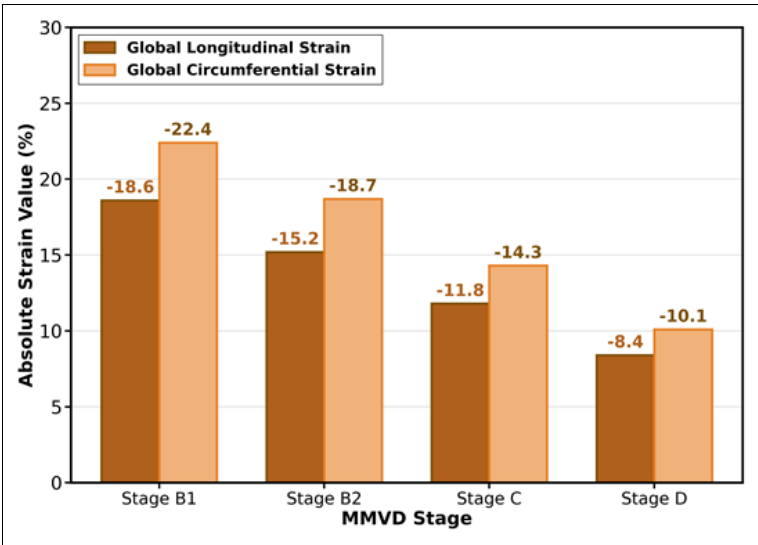


Fig 2: Global longitudinal strain (GLS) and global circumferential strain (GCS) values across MMVD stages B1 through D (values shown as actual negative strain percentages)

Table 2: Correlation between strain parameters and conventional echocardiographic indices

Pair	r value	p-value	R ²	Strength
GLS vs LA/Ao	0.82	<0.001	0.67	Strong
GLS vs LVIDd	0.76	<0.001	0.58	Strong
GCS vs LA/Ao	0.79	<0.001	0.62	Strong
GLS vs FS	-0.41	0.005	0.17	Moderate
GLS vs E/A	0.71	<0.001	0.50	Strong

GLS and GCS both demonstrated progressive deterioration across MMVD stages. The critical finding was that GLS at Stage B2 ($-15.2 \pm 1.9\%$) was already significantly worse than at B1 ($-18.6 \pm 2.1\%$, $p = 0.004$), while FS at B2 ($41.6 \pm 5.3\%$) actually appeared hyperdynamic compared to B1 ($38.2 \pm 4.1\%$, $p = 0.089$). This dissociation between strain and FS persisted into Stage C, where FS began declining while GLS continued its downward trajectory. Inter-observer coefficient of variation was 6.8% for GLS and 8.2% for GCS, indicating acceptable reproducibility.

Discussion

The progressive GLS decline from Stage B1 through D, with significant deterioration at Stage B2, is the most clinically important finding. Conventional FS remained normal or supranormal at Stage B2—a phenomenon attributed to volume overload-driven preload increases masking contractile dysfunction^[1, 10]. The 2D-STE approach bypasses this confound because strain reflects intrinsic myocardial deformation rather than chamber-level mechanics^[3]. Our B1 GLS value (-18.6%) aligns with published normal ranges of -17% to -21% ^[5, 6]. The B2 value of -15.2% falls below these references, suggesting subclinical impairment begins before the accepted threshold for pimobendan initiation. The EPIC trial data already hint at earlier intervention for Stage B2 dogs with cardiomegaly^[11]. The strong GLS-LA/Ao correlation ($r = 0.82$) indicates strain worsens in parallel with atrial remodelling from progressive mitral regurgitation^[12].

Limitations

This cross-sectional analysis cannot infer temporal progression within individual dogs. The sample of 45 dogs limited subgroup analyses by breed. Stage D cases ($n = 8$) were few. 2D-STE requires high frame rates and optimal image quality, potentially limiting general practice applicability.

Conclusion

The principal contribution is demonstrating that 2D-STE detects subclinical LV dysfunction at MMVD Stage B2 when conventional FS remains misleadingly normal. GLS showed the clearest stage-dependent deterioration and correlated strongly with LA/Ao ratio. These data support incorporating strain analysis into routine MMVD staging to enable earlier identification of dogs at risk of decompensation. Whether strain-guided treatment initiation improves outcomes and what breed-specific GLS thresholds should trigger concern remain open questions.

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