

## A study of descriptive values of echocardiography in unanesthetized Syrian hamsters

Kasidit Ladkhoksung<sup>1</sup> Nattapart Lerdkarnvijai<sup>1</sup> Thanakorn Ngamsawat<sup>1</sup>  
Napassorn Khemapunmanus<sup>1</sup> Suphisara Chantharadech<sup>1</sup> Pattharat Asvaesontorn<sup>2</sup>  
Thawat Lekdumrongsak<sup>3\*</sup> Sirilak Disatian Surachetpong<sup>3\*</sup>

### *Abstract*

The Syrian hamster (*Mesocricetus auratus*) is the most commonly presented hamster species in veterinary practice, yet descriptive echocardiographic values remain limited, particularly under conscious conditions. This study aimed to establish normal two-dimensional, M-mode, and Doppler echocardiographic values in healthy conscious Syrian hamsters and to evaluate the influence of age, body weight, and sex on cardiac parameters. Forty Syrian hamsters (27 males and 12 females; one excluded) underwent physical examination, thoracic radiography, and echocardiography. Age and body weight were recorded. Echocardiographic parameters were analyzed for their distribution and correlation with age and body weight. All echocardiographic parameters demonstrated a normal distribution. Age and body weight correlated with several echocardiographic measurements, whereas no significant differences were observed between males and females. The study established baseline echocardiographic values for conscious Syrian hamsters, including two-dimensional, M-mode, and Doppler indices.

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**Keywords:** descriptive values, echocardiography, exotic pets, heart, Syrian hamsters

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<sup>1</sup>16<sup>th</sup> year Veterinary Student, Faculty of Veterinary Science, Chulalongkorn University, Bangkok 10330, Thailand

<sup>2</sup>Exotic Pet Clinic, Faculty of Veterinary Science, Chulalongkorn University, Bangkok 10330, Thailand

<sup>3</sup>Department of Veterinary Medicine, Faculty of Veterinary Science, Chulalongkorn University, Bangkok 10330, Thailand

\*Correspondence: ithawat@hotmail.com (T. Lekdumrongsak), sirilak.d@chula.ac.th (S. D. Surachetpong)

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## Introduction

Currently, the population of pet owners is increasing significantly, expanding not only from dogs and cats but also to include exotic animals. Among these exotic pets, hamsters are among the most commonly kept, with various species including the Syrian (*Mesocricetus auratus*), Winter White (*Phodopus sungorus*), Roborovski (*Phodopus roborovskii*), and Campbell's (*Phodopus campbelli*) hamsters. The Syrian hamster is the most popular species and is frequently seen in clinical practice (Miwa and Mayer, 2021; O'Neill *et al.*, 2022).

In clinical settings, a wide range of diseases has been reported in hamsters, similar to those seen in other animal species, with cardiac disease being particularly prominent. According to a study conducted by Ottenweller *et al.* (1987), aging hamsters afflicted with cardiac conditions demonstrate accelerated cardiac and vascular alterations compared to their healthier counterparts. Moreover, congestive heart failure can precipitate atrial thrombosis in more than 70% of aged hamsters. Both atrial thrombosis and congestive heart failure are notably prevalent among older hamsters (Miedel and Hankenson, 2015; Quesenberry and Donnelly, 2020). The most common cardiac diseases in hamsters are cardiomyopathies, such as dilated cardiomyopathy (Belfiore *et al.*, 2011). These conditions are typically diagnosed in hamsters aged one year or older, including those with chronic illnesses. Left atrial thrombi occur in most cases, predominantly adhering to the endocardium and potentially expanding into adjacent cardiac chambers (Miedel and Hankenson, 2015), which is particularly noteworthy given the relatively short average lifespan of hamsters (approximately 1.75 years) (O'Neill *et al.*, 2022).

Diagnosis of heart diseases involves the use of radiography and ultrasound, in conjunction with clinical signs. Hamsters with cardiac conditions are typically older and may present with symptoms such as lethargy, anorexia, tachycardia, cyanosis, respiratory distress, peripheral edema, and cold extremities (Miwa and Mayer, 2021). The primary challenge in rodent radiology is the difficulty in achieving accurate thoracic diagnosis, as it primarily displays organ silhouettes and provides little information about internal anatomical structures (Yitbarek and Dagnaw, 2022).

Echocardiography, or ultrasonography, is a method used to examine the heart and major blood vessels by sending echo waves to various regions of the heart and processing the reflected signals into two- or three-dimensional images. Moreover, hamsters can undergo this examination without the need for sedation or general anesthesia (Pereira and Pizzi, 2012). This is particularly advantageous because anesthetic agents are known to affect systolic function and may consequently alter cardiovascular parameters (Tanaka *et al.*, 2016). Echocardiography, therefore, allows real-time assessment of the heart's physical characteristics and function in a minimally invasive manner (Barros Filho *et al.*, 2021).

However, there are few studies on echocardiography in Syrian hamsters, especially in

conscious individuals. Thus, the aim of this study was to establish descriptive values for two-dimensional, M-mode, and Doppler echocardiographic parameters in healthy, conscious Syrian hamsters. These findings may aid in improving the diagnosis and treatment of cardiovascular diseases in Syrian hamsters.

## Materials and Methods

**Study location and period:** This study was conducted at the Small Animal Teaching Hospital, Faculty of Veterinary Science, Chulalongkorn University, Thailand. Written informed consent was obtained from all hamster owners. General history, physical examination findings, radiographic data, and echocardiographic data of 40 healthy Syrian hamsters (Modified from Casamian-Sorrosal *et al.* 2014; Ngosurachet *et al.* 2022) were collected between 29 January 2025 and 6 August 2025.

**Animals and study design:** This prospective study was conducted in accordance with the ethical principles and guidelines for the use of animals for scientific purposes, as established by the National Research Council of Thailand, and was approved by the Institutional Animal Care and Use Committee, Faculty of Veterinary Science, Chulalongkorn University (Protocol no. 2031075).

Forty healthy Syrian hamsters were recruited from private pet owners. The inclusion criteria used for recruitment were an age of 6 months to 1.5 years, a body weight of less than or equal to 200 grams, and a clinically healthy status, defined as the absence of clinical signs or a history of cardiovascular or other systemic diseases. Data recorded from each hamster included age, breed, sex, neutering status, weight, and body condition score. All hamsters were examined by a veterinarian specializing in exotic animal medicine. A physical examination was performed to confirm a clinically normal health status. Radiography and echocardiography were performed without sedation or general anesthesia.

**Thoracic radiography:** Two standard radiographic projections (right lateral and ventrodorsal views) were performed. The thoracic radiographs included all ribs, the diaphragm, and the cranial abdomen. For the lateral projection, the Syrian hamsters were placed in the right lateral position with the thoracic limbs extended cranially.

**Echocardiography:** Echocardiography was performed by a single operator (SS) using an ultrasound machine (M9, Mindray, China) equipped with a 4-12 MHz phased-array transducer to evaluate cardiac structure and function. The Syrian hamsters were placed in lateral recumbency and were shaved bilaterally over the thoracic region, where the ultrasound probe was positioned for examination. All echocardiographic measurements were performed over three consecutive cardiac cycles. Echocardiographic parameters were assessed in a total of 39 hamsters, all of which were evaluated by a single experienced ultrasonographer to minimize interobserver variability and reduce bias. Electrocardiography and echocardiography

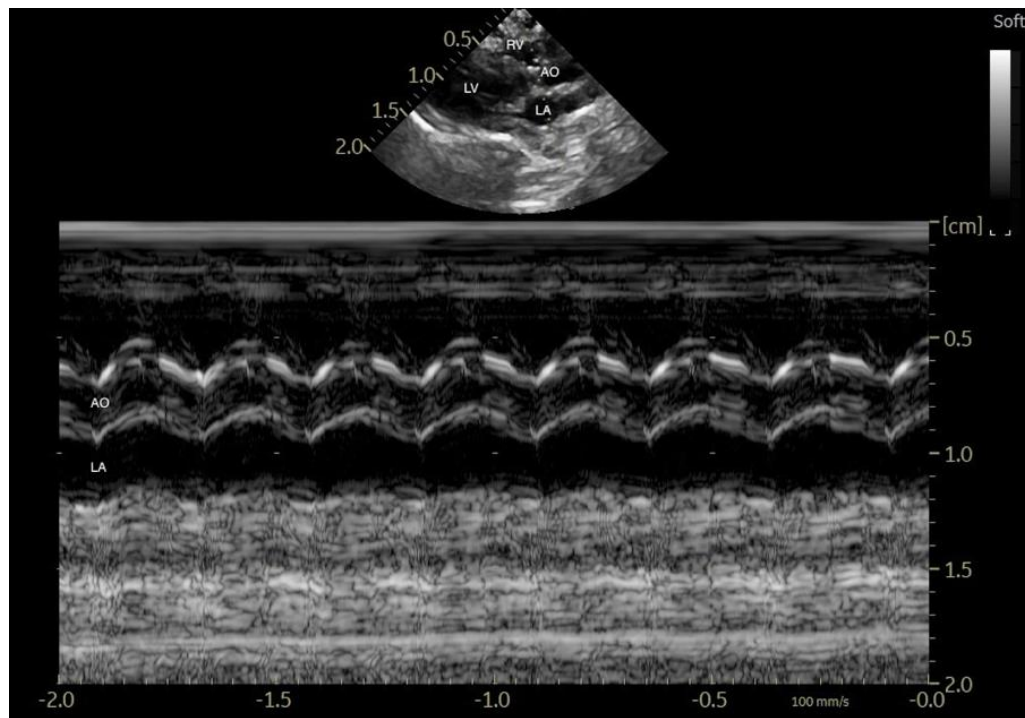
evaluations were performed separately, as the hamsters were uncomfortable with electrode placement when not under anesthesia. Two-dimensional echocardiography was used to measure the diameter of the left atrium (LA) and aorta (Ao) during early diastole, at the time of aortic valve closure, at the level of the aortic root, and at the aortic valve in the right parasternal short-axis view. The ratio of the left atrial to aorta diameter (LA/Ao) was automatically calculated using the ultrasound system's software. M-mode echocardiography was performed to measure cardiac chamber dimensions and myocardial wall thickness in the right parasternal long-axis view (Fig. 1). The M-mode cursor was placed perpendicular to the interventricular septum and the left ventricular wall, just below the mitral valve leaflets. Echocardiographic parameters, including the interventricular septal thickness at end-diastole (IVSd) and end-systole (IVSs), left ventricular internal dimension at end-diastole (LVIDd) and systole (LVIDs), and left ventricular posterior wall thickness at end-diastole (LVPWd) and end-systole (LVPWs), were measured. Fractional shortening (FS) was calculated automatically using the ultrasound system's software. Left atrial (LA) and aortic diameters (Ao) were measured at the level of the aortic valve, and the ratio of the left atrial to aorta diameter (LA/Ao) was calculated (Fig. 2). During Doppler echocardiography, transmitral flow velocity was measured in the left apical four-chamber view. Measurements were obtained when the mitral valve was fully open, with the sample volume placed at the tips of the mitral valve leaflets. The following parameters were recorded: early diastolic transmitral flow peak velocity (E), late diastolic transmitral flow peak velocity (A), and the

ratio between peak early diastolic and late diastolic transmitral flow velocities (E/A). If the E and A waves were not separated due to a high heart rate, E-A summation was reported instead. Isovolumetric relaxation time (IVRT) was measured by placing the sample volume in the left ventricular outflow tract near the mitral valve leaflets in the left apical five-chamber view. Aortic flow velocity was also measured in the left apical five-chamber view and expressed as the maximum aortic outflow velocity (AV). Assessment of pulmonary artery flow was performed in the right parasternal short-axis view, and the maximum pulmonary outflow velocity (PV) was recorded. The frame rate of at least 100 fps was used.

**Statistical analyses:** Statistical analyses were performed using IBM SPSS Statistics software (version 28.0.0; IBM Corp., Chicago, IL, USA). The Shapiro-Wilk test was applied to assess data normality. Descriptive statistics were calculated for each parameter and are presented as minimum, maximum, mean, and standard deviation (SD) for normally distributed data. For non-normally distributed data (Shapiro-Wilk test,  $P < 0.05$ ), results were primarily presented as median and interquartile range (IQR); however, mean  $\pm$  SD values were also reported for descriptive purposes. Differences between male and female Syrian hamsters were analyzed using Student's *t*-test or the Mann-Whitney U test, as appropriate. Correlations between echocardiographic parameters and body weight or age were evaluated using Pearson's or Spearman's correlation coefficients, depending on data distribution. Statistical significance was defined as  $P < 0.05$ .



**Figure 1** Two-dimensional echocardiography in the right parasternal long-axis view at the level of the left ventricular outflow tract. LA: left atrium, AO: aorta, LV: left ventricle.



**Figure 2** M-mode echocardiography of the left atrium (LA) and aorta (AO) from the right parasternal long-axis view at the level of the left ventricular outflow tract. LA: left atrium, AO: aorta, LV: left ventricle.

**Table 1** Values of two-dimensional, M-mode and Doppler echocardiographic variables measured in 39 conscious Syrian hamsters.

| Parameter                   | Range (Min-Max) | Mean $\pm$ SD     | n  |
|-----------------------------|-----------------|-------------------|----|
| <b>2D measurements</b>      |                 |                   |    |
| LA (mm)                     | 1.2-3.6         | 2.47 $\pm$ 0.53   | 39 |
| Ao (mm)                     | 1.1-2.7         | 1.87 $\pm$ 0.38   | 39 |
| LA/Ao                       | 0.91-1.87       | 1.34 $\pm$ 0.25   | 39 |
| <b>M-mode measurements</b>  |                 |                   |    |
| IVSd (mm)                   | 0.6-2.2         | 1.28 $\pm$ 0.30   | 39 |
| IVSs (mm)                   | 1.0-2.9         | 1.73 $\pm$ 0.98   | 39 |
| LVIDd (mm)                  | 2.9-6.8         | 5.04 $\pm$ 0.98   | 39 |
| LVIDs (mm)                  | 1.92-5.12       | 3.66 $\pm$ 0.72   | 39 |
| LVIDs (mm)                  | 0.9-5.9         | 3.29 $\pm$ 1.13   | 39 |
| LVPWd (mm)                  | 0.6-2.7         | 1.20 $\pm$ 0.38   | 39 |
| LVPWs (mm)                  | 0.5-3.7         | 1.72 $\pm$ 0.66   | 39 |
| FS (%)                      | 11.76-76.56     | 36.01 $\pm$ 14.89 | 39 |
| <b>Doppler measurements</b> |                 |                   |    |
| E (cm/s)                    | 56.26-89.24     | 70.02 $\pm$ 9.00  | 14 |
| A (cm/s)                    | 27.13-51.22     | 39.56 $\pm$ 7.27  | 14 |
| E/A                         | 1.23-2.51       | 1.82 $\pm$ 0.34   | 14 |
| E-A summation               | 53.19-96.74     | 76.24 $\pm$ 9.28  | 25 |
| IVRT (ms)                   | 16-47           | 29.87 $\pm$ 6.69  | 39 |
| AV (cm/s)                   | 33.91-104.59    | 75.07 $\pm$ 18.66 | 39 |
| PV (cm/s)                   | 40.34-109.59    | 74.28 $\pm$ 16.66 | 39 |

LA, diameter of the left atrium; Ao, diameter of the aorta; LA/Ao, the ratio of left atrial to aorta diameter; IVSd, interventricular septal thickness at end diastole; IVSs, interventricular septal thickness at end systole; LVIDd, left ventricular internal dimension at end diastole; LVIDs, left ventricular internal dimension at end systole; LVIDs (mm), left ventricular internal dimension at end systole; LVPWd, left ventricular posterior wall thickness at end diastole; LVPWs, left ventricular posterior wall thickness at end systole; FS, fractional shortening measured and calculated by the internal ultrasound system software; E, early diastolic transmitral flow peak velocity; A, late transmitral flow peak velocity; E/A, the ratio between peak early diastolic and late diastolic transmitral flow velocities; E-A summation, summation of peak early diastolic and late diastolic transmitral flow velocities; IVRT, isovolumetric relaxation time; AV, maximum velocity of aortic outflow; PV, maximum velocity of pulmonary outflow.

## Result

Forty Syrian hamsters were recruited for the study. One hamster had abnormal findings during physical examination and was therefore excluded. All remaining 39 hamsters underwent physical examination, thoracic radiography, and echocardiography (Table 1). No abnormal findings were detected on physical examination in the included

hamsters. Of the 39 Syrian hamsters included, 27 were males (69.23%), and 12 were females (30.77%). All animals were intact. The age and body weight of the hamsters were recorded and expressed as minimum, maximum, mean, and standard deviation (S.D.). The minimum and maximum ages were 6 and 18 months, respectively, with a mean age  $\pm$  S.D. of 10.21  $\pm$  4.47 months. The minimum and maximum body weights were 93 and 200 g, respectively, with a mean weight  $\pm$  S.D. of 139.64  $\pm$  22.90 g. The minimum and maximum

heart rates were 208 and 427 bpm, respectively, with a mean heart rate  $\pm$  S.D. of  $210 \pm 10.55$  bpm.

Prior to echocardiography, all Syrian hamsters were confirmed to be in good health. Correlations

between the independent variables and echocardiographic parameters are presented in Tables 2 and 3.

**Table 2** Pearson's correlation analysis of age with two-dimensional, M-mode, and Doppler echocardiographic parameters in 39 Syrian hamsters.

| Parameters     | r       | P-value |
|----------------|---------|---------|
| LA (2D)        | 0.132   | 0.423   |
| Ao (2D)        | 0.281   | 0.083   |
| LA/Ao (2D)     | -0.092  | 0.597   |
| IVSd           | 0.331*  | 0.040   |
| IVSs           | 0.568** | < 0.001 |
| LVIDd          | -0.072  | 0.665   |
| LVIDs          | -0.265  | 0.104   |
| LVPWd          | 0.401*  | 0.011   |
| LVPWs          | 0.603** | < 0.001 |
| FS             | 0.446** | 0.004   |
| LA (M-mode)    | 0.045   | 0.783   |
| Ao (M-mode)    | 0.461** | 0.003   |
| LA/Ao (M-mode) | -0.357* | 0.026   |
| E              | -0.116  | 0.692   |
| A              | 0.455   | 0.102   |
| E/A            | -0.444  | 0.111   |
| E-A summation  | -0.299  | 0.147   |
| IVRT           | 0.179   | 0.276   |
| AV             | 0.066   | 0.692   |
| PV             | -0.086  | 0.603   |

LA, diameter of the left atrium; Ao, diameter of the aorta; LA/Ao, the ratio of left atrial to aorta diameter; IVSd, interventricular septal thickness at end diastole; IVSs, interventricular septal thickness at end systole; LVIDd, left ventricular internal dimension at end diastole; LVIDs, left ventricular internal dimension at end systole; LVPWd, left ventricular posterior wall thickness at end diastole; LVPWs, left ventricular posterior wall thickness at end systole; FS, fractional shortening measured and calculated by the internal ultrasound system software; E, early diastolic transmitral flow peak velocity; A, late transmitral flow peak velocity; E/A, the ratio between peak early diastolic and late diastolic transmitral flow velocities; E-A summation, summation of peak early diastolic and late diastolic transmitral flow velocities; IVRT, isovolumetric relaxation time; AV, maximum velocity of aortic outflow; PV, maximum velocity of pulmonary outflow.

\*Correlation values are significantly ( $P < 0.05$ ) related to the echocardiographic parameter.

\*\*Correlation values are highly significant ( $P < 0.01$ ) related to the echocardiographic parameter.

**Table 3** Pearson's correlation analysis of body weight with two-dimensional, M-mode, and Doppler echocardiographic parameters in 39 Syrian hamsters.

| Parameters     | r      | P-value |
|----------------|--------|---------|
| LA (2D)        | 0.285  | 0.079   |
| Ao (2D)        | 0.195  | 0.233   |
| LA/Ao (2D)     | 0.128  | 0.404   |
| IVSd           | 0.065  | 0.694   |
| IVSs           | 0.074  | 0.655   |
| LVIDd          | 0.382* | 0.016   |
| LVIDs          | 0.181  | 0.271   |
| LVPWd          | 0.105  | 0.526   |
| LVPWs          | 0.179  | 0.276   |
| FS             | 0.064  | 0.700   |
| LA (M-mode)    | 0.355* | 0.027   |
| Ao (M-mode)    | 0.085  | 0.605   |
| LA/Ao (M-mode) | 0.200  | 0.222   |
| E              | -0.091 | 0.758   |
| A              | 0.045  | 0.879   |
| E/A            | -0.066 | 0.822   |
| E-A summation  | 0.082  | 0.698   |
| IVRT           | -0.210 | 0.200   |
| AV             | 0.038  | 0.818   |
| PV             | -0.137 | 0.406   |

LA, diameter of the left atrium; Ao, diameter of the aorta; LA/Ao, the ratio of left atrial to aorta diameter; IVSd, interventricular septal thickness at end diastole; IVSs, interventricular septal thickness at end systole; LVIDd, left ventricular internal dimension at end diastole; LVIDs, left ventricular internal dimension at end systole; LVPWd, left ventricular posterior wall thickness at end diastole; LVPWs, left ventricular posterior wall thickness at end systole; FS, fractional shortening measured and calculated by the internal ultrasound system software; E, early diastolic transmitral flow peak velocity; A, late transmitral flow peak velocity; E/A, the ratio between peak early diastolic and late diastolic transmitral flow velocities; E-A summation, summation of peak early diastolic and late diastolic transmitral flow velocities; IVRT, isovolumetric relaxation time; AV, maximum velocity of aortic outflow; PV, maximum velocity of pulmonary outflow.

\*Correlation values are significantly ( $P < 0.05$ ) related to the echocardiographic parameter.

## Discussion

Studies on echocardiographic values in Syrian hamsters of various ages and different sexes are limited. Only two studies were found. These studies were performed in 10- and 12- week-old female Syrian hamsters under anesthesia (Selami *et al.*, 2005; Barros Filho *et al.*, 2021). Therefore, this study is the first to provide descriptive echocardiographic values for 39 healthy, non-sedated adult Syrian hamsters of various ages and both sexes. The association between age, body weight, and cardiac measurements was also explored.

The right parasternal long-axis view was used in this study because it is easier to assess and measure wall thickness and chamber size. Due to the very small heart size in the Syrian hamster, obtaining the exact short-axis view at the papillary muscle level is challenging. However, measurements from different imaging planes may not yield identical values. As suggested in a study on dogs, the data obtained from LV short-axis and long-axis M-mode should not be used interchangeably (Schober and Baade, 2000).

During echocardiography, restraint difficulties were encountered because the hamsters were conscious and unanesthetized; as a result, parameters such as E wave and A wave could not be clearly interpreted in some hamsters due to their very high heart rates.

Statistical analysis of echocardiographic parameters demonstrated correlations between age, body weight, and several echocardiographic variables. Specifically, positive correlations were observed between age and IVSd, IVSs, LVPWd, LVPWs, FS, and Ao. In contrast, age was negatively correlated with LA/Ao. The positive correlation between age and wall thickness parameters may reflect age-related myocardial remodeling or hypertrophy, a finding that has also been reported in aging mice (Dai *et al.*, 2009). The aortic root diameter (Ao) measured using M-mode increased significantly with age, with previous findings indicating that large arterial structures gradually dilate as part of normal vascular aging (Ahmed *et al.*, 2024). Because Ao appears to be age dependent, the commonly used LA/Ao ratio should be interpreted with caution. A decrease in LA/Ao with age in this study does not necessarily reflect a reduction in left atrial size but may instead indicate age-related expansion of the aortic root. This concept parallels findings in human cardiology, where the LA/Ao ratio may be biased in older individuals due to progressive aortic dilation (Patel *et al.*, 2022). Further studies incorporating distinct age groups, such as juvenile, adult, and geriatric populations, are necessary to determine whether these correlations represent true physiological trends or sampling-related effects.

In contrast, body weight showed positive correlations with LVIDd and LA (M-mode), indicating that heavier hamsters tend to have larger ventricular and atrial dimensions. Similar patterns are observed across many species, in which chamber size scales with body mass (Casha *et al.*, 2017). Therefore, establishing weight-indexed normal values, such as LVIDd/BW or LA/BW (Table 1), would improve the applicability of these measurements in clinical assessments. Indexing cardiac dimensions reduces the risk of

misinterpretation when assessing animals of varying body sizes, particularly in species such as hamsters, which show a wide adult weight range.

Our findings may provide a preliminary representation of the healthy Syrian hamster population in Thailand. This study has several limitations. The sample size was relatively small and derived from a single population, which is not appropriate for generating a reference range for the broader Syrian hamster population. All echocardiographic assessments were performed under non-sedated and unanesthetized conditions. Although image acquisition was more challenging in conscious animals, this approach may better reflect physiological cardiac function compared to anesthetized conditions, where cardiac performance is often suppressed. Additionally, the high heart rate of hamsters can complicate Doppler measurements, particularly for diastolic function assessment. Finally, the cross-sectional nature of the study precludes the evaluation of longitudinal changes.

In conclusion, echocardiographic measurements obtained from 39 conscious Syrian hamsters were used to establish descriptive echocardiographic values for this species. The effects of body weight and age on these parameters were also evaluated, while sex was found to have no significant impact. Overall, the results of this study provide baseline echocardiographic values that may serve as data for clinical assessment and future research involving Syrian hamsters.

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**Conflict of interest:** The authors declare they have no conflict of interest

**CRedit authorship contribution statement:** **Kasidit Ladkhoksung:** Investigation, Data analysis, Writing – original draft. **Nattapart Lerdkarnvijai:** Investigation, Data analysis, Writing – original draft. **Thanakorn Ngamsawat:** Investigation, Data analysis, Writing – original draft. **Napassorn Khemapunmanus:** Investigation, Data analysis, Writing – original draft. **Suphisara Chantharadech:** Investigation, Data analysis, Writing – original draft. **Pattharat Asvaesoonorn:** Project administration, Investigation, Resources. **Thawat Lekdumrongsak:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Sirilak Disatian Surachetpong:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology,

Validation, Visualization, Writing – review & editing.

**Declaration of artificial intelligence use:** During the preparation of this work, the authors used ChatGPT for English language correction.

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