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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии
საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებშიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman (Кириллица)**, для текста на грузинском языке следует использовать **AcadNusx**. Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи.** Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - <http://www.spinesurgery.ru/files/publish.pdf> и http://www.nlm.nih.gov/bsd/uniform_requirements.html. В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректуре авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or computer-printed on a single side of standard typing paper, with the left margin of 3 centimeters width, and 1.5 spacing between the lines, typeface - **Times New Roman (Cyrillic)**, print size - 12 (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf

In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

ავტორთა საყურადღებო!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე, დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx**. შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემავსებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრაფიის ფოტოსურათები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შედეგების ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფხიხლებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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CARDIAC STRAIN IN WOMEN WITH A DOCUMENTED HISTORY OF OVERT OR SUBCLINICAL HYPOTHYROIDISM: AN EXPLORATORY SPECKLE-TRACKING ECHOCARDIOGRAPHY STUDY

Abramishvili T^{1*}, Papava K^{1,2}, Mamisashvili M³, Tkeshelashvili M³, Tsinamdzgvrishvili B¹.

¹Tbilisi Ivane Javakhishvili State University, Tbilisi, Georgia.

²Tbilisi Institute of Medicine, Tbilisi, Georgia.

³Ken Walker International University, Tbilisi, Georgia.

Abstract.

Aim: To compare conventional and speckle-tracking echocardiographic parameters, with a prespecified focus on left atrial (LA) contractile strain, between women with a documented history of hypothyroidism and euthyroid controls.

Material and methods: This retrospective case-control analysis included 86 women: 36 with a previously documented diagnosis of overt or subclinical hypothyroidism and 50 controls documented as euthyroid. The hypothyroid cohort was clinically heterogeneous and included treated and untreated participants; 31 (86.1%) were receiving L-thyroxine. Conventional transthoracic echocardiography and two-dimensional speckle-tracking analysis were evaluated. LA contractile strain was the prespecified primary outcome; other echocardiographic comparisons were exploratory. Multivariable linear regression adjusted for age, body mass index, diastolic blood pressure, and heart rate.

Results: The hypothyroid group was younger than controls. Left ventricular ejection fraction was preserved in both groups. Hypothyroid participants had lower LV volumes, LA volume index, pulmonary artery systolic pressure, and right-ventricular (RV) S'. RV free-wall strain and the magnitude of LA contractile strain were lower, whereas LV global longitudinal strain, RV global longitudinal strain, LA reservoir strain, and LA conduit strain did not differ. In the subset with available free thyroxine data (n=21), FT4 correlated with signed LA contractile strain ($p=0.524$, $p=0.015$). After adjustment, hypothyroidism was not independently associated with LA contractile strain ($B=2.634$, 95% CI -0.081 to 5.349; $p=0.057$); heart rate remained independently associated ($B=-0.145$, 95% CI -0.263 to -0.027; $p=0.017$).

Conclusions: In this heterogeneous cohort of women with treated or untreated overt or subclinical hypothyroidism, unadjusted differences in RV free-wall and LA contractile strain were observed. The adjusted analysis did not establish an independent association between hypothyroidism and LA contractile strain. These exploratory findings require confirmation in prospectively recruited, age-matched cohorts with standardized biochemical phenotyping.

Key words. Hypothyroidism, speckle-tracking echocardiography, left atrial strain, contractile strain, right ventricular strain.

Introduction.

Hypothyroidism is common, particularly among women, and may influence cardiac function through changes in heart rate, myocardial calcium handling, vascular resistance, endothelial function, and ventricular relaxation [1-9]. Both

overt and subclinical thyroid dysfunction have been associated with changes in ventricular structure, diastolic performance, cardiovascular events, and mortality, although reported associations vary across populations and thyroid states [10-23].

Conventional echocardiographic measures such as chamber dimensions and left ventricular ejection fraction (LVEF) may remain normal during early myocardial dysfunction. Two-dimensional speckle-tracking echocardiography (2D-STE) quantifies myocardial deformation and may identify subtle abnormalities that are not apparent using conventional parameters [4,14]. Standardized deformation imaging also permits assessment of left atrial (LA) reservoir, conduit, and contractile phases [1].

Evidence specifically addressing LA mechanics in hypothyroidism remains limited. Moreover, thyroid cohorts often include different biochemical phenotypes and treatment states. The present study therefore evaluated women with a documented history of overt or subclinical hypothyroidism as a heterogeneous clinical group rather than as a uniform untreated biochemical phenotype. We prespecified LA contractile strain as the primary echocardiographic outcome and treated other comparisons as exploratory. The aim was to compare conventional and strain-derived echocardiographic parameters between this cohort and euthyroid controls, and to determine whether group status remained associated with LA contractile strain after adjustment for major clinical confounders.

Materials and Methods.

Study design and participants:

This was a single-center retrospective case-control analysis of a pre-existing clinical and echocardiographic dataset assembled during 2024-2025 in the endocrinology department of a multiprofile clinic. The analytic cohort comprised 86 women: 36 with a documented prior diagnosis of hypothyroidism and 50 volunteers documented as euthyroid. Clinical, laboratory, and echocardiographic records were analyzed retrospectively. Consent had been obtained for the original clinical evaluation; the present report does not describe prospective assignment of exposure or intervention.

The hypothyroid cohort included patients documented in the source records as having overt or subclinical hypothyroidism and included both treated and untreated individuals. Thirty-one of 36 participants (86.1%) were receiving L-thyroxine at evaluation. Some treated participants had achieved biochemical euthyroidism. A complete cross-classification by original biochemical phenotype, current biochemical status, etiology, disease duration, treatment duration, and L-thyroxine dose was not retained in the analytic dataset; therefore, unsupported

subgroup estimates were not generated. This limitation is reflected in the title, interpretation, and conclusions.

The original operational classification identified overt disease from the documented diagnosis and thyroid testing, including elevated thyroid-stimulating hormone (TSH) with reduced free thyroxine (FT4), and subclinical disease from elevated TSH with FT4 within the laboratory reference interval. A TSH value greater than 10 mIU/L was considered strongly supportive of overt thyroid failure but was not treated as sufficient without consideration of FT4 and the clinical record. The laboratory-specific FT4 unit and reference interval were not recoverable from the exported analytic dataset; consequently, the potentially ambiguous FT4 distribution is not reproduced. Rank-based FT4 correlations are retained because they are invariant to linear unit conversion, but they are explicitly reported as subset, exploratory analyses. Controls were classified as euthyroid in the source clinical records; FT4 measurements were not available for controls.

Women younger than 73 years were eligible. Exclusion criteria were atrial fibrillation, other clinically significant arrhythmia, frequent ectopy, untreated or treatment-requiring arterial hypertension, significant valvular heart disease, and medication use expected to materially affect heart rate, blood pressure, or cardiac function. Mild valvular disease and obesity were permitted. Menopausal women were included, but none received hormone-replacement therapy. The retained dataset did not contain a complete screening log or counts for each exclusion reason. The final analytic denominator was 86; variable-specific denominators are reported where data were incomplete.

Echocardiographic assessment:

Comprehensive transthoracic echocardiography included two-dimensional, Doppler, and tissue-Doppler measurements obtained using guideline-directed methods [12,16]. Recorded variables available for the present analysis included LV end-diastolic and end-systolic volumes, LV end-diastolic diameter, LVEF, LA volume index, E/e', pulmonary artery systolic pressure (PASP), and peak systolic tricuspid annular tissue velocity (RV S'). Although the source protocol referred to interventricular septal thickness, posterior-wall thickness, LV mass, tricuspid annular plane systolic excursion, and fractional area change, complete analyzable group-level exports for these variables were not available; they were therefore omitted rather than selectively or imprecisely reconstructed. Indexing of LA volume to body surface area was performed to reduce body-size dependence; indexed LV volumes were not available in the retained export and raw LV volumes are reported.

Speckle-tracking echocardiography:

Offline 2D-STE analysis was performed with vendor-specific QLAB software, version 10. Images used for deformation analysis had frame rates of 50-80 frames/s. LV and RV strain analyses followed contemporary deformation-imaging recommendations [1,14]. LA strain was measured from the apical four-chamber view only and was not a biplane average. The LA appendage and pulmonary veins were excluded from endocardial tracing. Studies with image quality or frame rate insufficient for analysis were excluded before creation of the analytic dataset; the number of such exclusions was not retained.

The ultrasound-system and transducer identifiers, number of averaged cardiac cycles, formal blinding status, segment-level tracking criteria, and frequency of manual contour correction were not preserved in the export and cannot be reported retrospectively. This incomplete technical metadata and absence of reproducibility testing are acknowledged as limitations.

R-R gating was used. Reservoir strain was defined as peak positive LA strain during ventricular systole. Conduit strain represented passive atrial emptying in early diastole, and contractile strain represented active deformation during late diastole. Tables report signed values: reservoir strain is positive, while conduit and contractile strain are negative. For the negative parameters, values closer to zero indicate a smaller absolute magnitude of deformation. All correlation and regression analyses used the signed LA contractile-strain value; thus, a positive coefficient corresponds to a value becoming less negative, not to greater absolute shortening.

Ethics:

The study was conducted in accordance with the Declaration of Helsinki. The source submission documented review by the local institutional ethics committee and written informed consent from participants before the original evaluation.

Statistical analysis:

Analyses were performed using SPSS version 29.0. Normality was assessed with the Shapiro-Wilk test. Normally distributed variables are presented as mean $\pm$ standard deviation and compared with the independent-samples Student t test; non-normally distributed variables are presented as median (interquartile range) and compared with the Mann-Whitney U test. Cohen d and rank-based r are reported as effect sizes for parametric and nonparametric comparisons, respectively. Spearman rank correlation (ρ) was used for thyroid measures and echocardiographic variables. Two-sided $p < 0.05$ was considered statistically significant.

LA contractile strain was the prespecified primary echocardiographic outcome. Other between-group comparisons and all correlation analyses were secondary or exploratory. Because numerous exploratory tests were performed, no single secondary p value is interpreted as confirmatory. No multiplicity adjustment was applied; the resulting risk of type I error is emphasized in the interpretation and limitations.

A multivariable linear regression modeled signed LA contractile strain as the dependent variable. Hypothyroidism was coded 1 and control status 0. Prespecified covariates were age, body mass index (BMI), diastolic blood pressure (DBP), and heart rate. We report unstandardized coefficients, 95% confidence intervals, standardized coefficients, t statistics, p values, variance inflation factors (VIFs), the intercept, R^2 , adjusted R^2 , model F statistic, and overall model p value. Residual plots and multicollinearity diagnostics were examined; all VIFs were below 2.10. Complete-case sample size for the model was 86. FT4 correlations used only the 21 participants with an available FT4 result; no imputation was performed.

Results.

The analysis included 36 women with a documented history of hypothyroidism and 50 euthyroid controls. The hypothyroid group was significantly younger. BMI, blood pressure, and

heart rate did not differ significantly, although BMI and heart rate showed borderline unadjusted differences. Thirty-one hypothyroid participants (86.1%) were receiving L-thyroxine (Table 1).

Hypothyroid participants had lower LV end-diastolic and end-systolic volumes, LA volume index, PASP, and RV S'. LVEF was preserved in both groups. LV end-diastolic diameter and E/e' did not differ significantly (Table 2).

Table 1. Baseline clinical and biochemical characteristics.

Variable	Controls (n=50)	Hypothyroid (n=36)	Mean difference (95% CI)	Effect size	p value
Age, years	54.0 (35.0-63.0)	36.0 (29.5-48.0)	—	r=0.23	0.030
BMI, kg/m ²	27.7 ± 6.7	25.0 ± 6.3	2.63 (-0.21 to 5.47)	d=0.41	0.069
SBP, mmHg	115.6 ± 9.8	113.1 ± 15.5	2.49 (-3.40 to 8.38)	d=0.20	0.401
DBP, mmHg	70.0 (63.0-75.0)	68.0 (59.5-73.5)	—	r=0.13	0.227
Heart rate, beats/min	76.4 ± 11.0	71.8 ± 11.0	4.60 (-0.20 to 9.31)	d=0.42	0.060
TSH, mIU/L	1.8 (1.3-2.4)	4.9 (2.2-7.8)	—	r=0.55	<0.001
FT4	Not available	Available in 21 participants; distribution omitted*	—	—	—
L-thyroxine therapy, n (%)	—	31 (86.1)	—	—	—

Note: Normally distributed variables are mean ± SD and non-normally distributed variables are median (IQR). Mean differences are calculated as control minus hypothyroid. Cohen d and rank-based r are effect sizes. *FT4 assay unit and reference interval were not recoverable; the potentially ambiguous distribution is therefore not reproduced. BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TSH, thyroid-stimulating hormone; FT4, free thyroxine.

Table 2. Conventional echocardiographic parameters.

Parameter	Controls (n=50)	Hypothyroid (n=36)	Mean difference (95% CI)	Effect size	p value
LVEDV, mL	66.0 (55.0-76.0)	54.0 (45.0-60.0)	—	r=0.32	0.003
LVESV, mL	23.7 ± 5.7	19.9 ± 5.5	3.74 (1.29 to 6.20)	d=0.68	0.003
LVEDD, cm	3.7 ± 1.4	4.1 ± 0.4	-0.36 (-0.79 to 0.07)	d=0.37	0.096
LVEF, %	63.0 (60.0-66.0)	63.0 (61.0-66.0)	—	r=0.22	0.046
LA volume index, mL/m ²	27.0 (24.0-30.0)	19.0 (17.0-26.0)	—	r=0.44	<0.001
E/e'	7.0 (6.0-9.0)	6.5 (5.5-8.0)	—	r=0.20	0.063
PASP, mmHg	30.0 (24.0-34.0)	26.0 (25.0-27.0)	—	r=0.39	<0.001
RV S', cm/s	13.0 (12.0-14.0)	12.0 (11.0-13.0)	—	r=0.33	0.002

Note: Normally distributed variables are mean ± SD and non-normally distributed variables are median (IQR). Mean differences are control minus hypothyroid. LVEDV, left-ventricular end-diastolic volume; LVESV, left-ventricular end-systolic volume; LVEDD, left-ventricular end-diastolic diameter; LVEF, left-ventricular ejection fraction; LA, left atrial; PASP, pulmonary artery systolic pressure; RV S', peak systolic tricuspid annular tissue velocity.

Table 3. Myocardial and atrial strain parameters.

Parameter	Controls (n=50)	Hypothyroid (n=36)	Effect size r	p value
LV GLS, %	-19.0 (-21.8 to -18.0)	-20.0 (-21.8 to -18.3)	0.10	0.353
RV GLS, %	-23.0 (-24.8 to -20.3)	-22.0 (-25.0 to -19.3)	0.07	0.488
RV free-wall strain, %	-29.0 (-30.0 to -25.3)	-26.0 (-29.0 to -24.0)	0.23	0.033
LA reservoir strain, %	41.0 (38.0-50.8)	47.5 (34.3-55.8)	0.001	0.990
LA conduit strain, %	-22.5 (-31.3 to -19.0)	-28.5 (-37.8 to -18.0)	0.08	0.486
LA contractile strain, %	-20.0 (-22.8 to -18.3)	-15.0 (-24.0 to -11.0)	0.30	0.006

Note: Data are median (IQR). Signed strain values are reported. Less negative conduit and contractile values indicate lower absolute deformation. LV, left ventricular; RV, right ventricular; LA, left atrial; GLS, global longitudinal strain.

Table 4. Spearman correlations between thyroid measures and echocardiographic parameters.

Variable	TSH ρ (n=86)	TSH p value	FT4 ρ (n=21)	FT4 p value
LA reservoir strain	0.090	0.423	-0.325	0.151
LA conduit strain	-0.075	0.493	0.135	0.560
LA contractile strain	0.118	0.279	0.524	0.015
LV GLS	-0.005	0.960	0.363	0.106
LA volume index	-0.202	0.062	-0.047	0.840
E/e'	-0.234	0.030	0.012	0.957

Note: FT4 analyses are complete-case subset analyses (n=21); no imputation was performed. Signed LA strain values were used. ρ, Spearman rank correlation coefficient.

Table 5. Multivariable linear regression for signed LA contractile strain.

Predictor	B (95% CI)	Standardized β	t	p value	VIF
Hypothyroidism (1 vs 0)	2.634 (-0.081 to 5.349)	0.210	1.930	0.057	1.115
Age, years	0.044 (-0.066 to 0.154)	0.104	0.793	0.430	1.626
BMI, kg/m ²	0.050 (-0.182 to 0.282)	0.053	0.431	0.668	1.451
DBP, mmHg	-0.114 (-0.304 to 0.077)	-0.144	-1.187	0.239	1.390
Heart rate, beats/min	-0.145 (-0.263 to -0.027)	-0.258	-2.439	0.017	1.058
Constant	-4.705 (-19.158 to 9.749)	—	-0.648	0.519	—

Note: $n=86$; $R^2=0.152$; adjusted $R^2=0.099$; $F(5,80)=2.870$; model $p=0.020$. Hypothyroidism was coded 1 and control 0. Residual plots and multicollinearity diagnostics were examined; all VIFs were <2.10 . B, unstandardized coefficient; CI, confidence interval; VIF, variance inflation factor.

In exploratory deformation analyses, RV free-wall strain and signed LA contractile strain were less negative in the hypothyroid group. LV global longitudinal strain (GLS), RV GLS, LA reservoir strain, and LA conduit strain did not differ (Table 3). Because conduit and contractile strain are signed negative values, these differences indicate lower absolute deformation, not an increase in shortening.

TSH was available for all 86 participants. FT4 was available for 21 participants. FT4 correlated positively with signed LA contractile strain ($\rho=0.524$, $p=0.015$), meaning that higher FT4 ranks were associated with values closer to zero. Given the signed convention, subset size, incomplete assay metadata, and multiple exploratory correlations, this finding should not be interpreted as evidence of improved contractile mechanics. TSH correlated weakly and inversely with E/e' ($\rho=-0.234$, $p=0.030$); other correlations were not significant (Table 4).

The adjusted model was significant overall ($F[5,80]=2.870$, $p=0.020$) and explained 15.2% of variation in signed LA contractile strain (adjusted $R^2=0.099$). Hypothyroidism did not reach conventional statistical significance after adjustment ($B=2.634$, 95% CI -0.081 to 5.349; $p=0.057$). Heart rate was independently associated with LA contractile strain ($B=-0.145$, 95% CI -0.263 to -0.027; $p=0.017$). Age, BMI, and DBP were not independently associated. VIFs ranged from 1.058 to 1.626, providing no evidence of important multicollinearity (Table 5).

Discussion.

This exploratory study compared conventional and deformation-derived echocardiographic findings in euthyroid controls and a heterogeneous group of women with a documented history of overt or subclinical hypothyroidism, most of whom were receiving L-thyroxine. The principal observation was an unadjusted difference in signed LA contractile strain; however, group status was not independently associated with the primary outcome after adjustment for age, BMI, DBP, and heart rate. The confidence interval included the null and the p value was 0.057. Accordingly, the study does not establish a direct effect of thyroid dysfunction on atrial mechanics. Despite these findings, all participants demonstrated preserved left ventricular diastolic function and the hypothyroid group was relatively young. Therefore, the observed reduction in left atrial contractile strain is unlikely to be explained solely by age or diastolic dysfunction. Although these observations raise the possibility that hypothyroidism contributes to early impairment of left atrial mechanics, multivariable regression analysis did not identify hypothyroidism as an independent determinant of

reduced left atrial contractile strain. Accordingly, the observed association should be interpreted with caution and cannot be considered evidence of an independent causal effect.

The age imbalance is central to interpretation. Controls were older, and age can influence chamber size, loading conditions, diastolic indices, and myocardial deformation. Although age was included in the prespecified adjusted model for LA contractile strain, adjusted analyses were not performed for RV free-wall strain, LA volume index, or RV S'. Those findings therefore remain unadjusted secondary observations and may reflect age or other baseline differences. The non-significant age coefficient within one multivariable model does not eliminate confounding across the broader set of outcomes.

Conventional echocardiographic findings:

LVEF remained preserved in both groups, whereas LV volumes, LA volume index, PASP, and RV S' differed in unadjusted comparisons. Thyroid hormones influence contractility, relaxation, vascular tone, and hemodynamics [5,10,11,18,23], but the present design cannot attribute these differences to current thyroid-hormone deficiency. The hypothyroid group combined treated and untreated participants and some treated participants had achieved biochemical euthyroidism. Lower LA volume index in the younger hypothyroid group may also reflect age, body size, or loading conditions rather than impaired LA physiology. The RV S' and PASP findings likewise require cautious interpretation because they were not adjusted and arose among multiple exploratory comparisons.

Myocardial and atrial strain findings:

RV free-wall strain and LA contractile strain were less negative in the hypothyroid group, while LV GLS, RV GLS, LA reservoir strain, and LA conduit strain did not differ. Speckle-tracking methods can detect subtle myocardial deformation before changes in LVEF [4,14], but measurement is influenced by loading conditions, acquisition quality, software, and analytic conventions. The single-view LA method used here is not equivalent to recommended biplane LA strain assessment [1] and may reduce precision.

The FT4 correlation requires particular caution. It was based on only 21 available observations, and assay units and reference limits were not recoverable. Moreover, because signed contractile strain is negative, the positive correlation indicates higher FT4 associated with less negative values. It should not be described as greater absolute contractile deformation. The finding is therefore hypothesis-generating and requires verification with prospectively collected, standardized laboratory data.

In the adjusted primary-outcome model, heart rate remained associated with signed LA contractile strain, whereas hypothyroidism did not meet the prespecified significance threshold. The model explained a modest proportion of variance, suggesting that unmeasured biological, hemodynamic, and technical factors remain important. The results support further study of atrial mechanics in clearly phenotyped thyroid populations but do not support causal language or clinical screening recommendations.

Limitations.

This study has important limitations. First, the retrospective, single-center design and modest sample size limit generalizability and causal inference. Second, controls were substantially older, creating major potential confounding. Only the LA contractile-strain model was adjusted; RV free-wall strain, LA volume index, RV S', and other secondary outcomes remain unadjusted.

Third, the hypothyroid cohort combined overt and subclinical disease, treated and untreated patients, and participants with different current biochemical states. Complete subgroup counts, etiology, disease duration, treatment duration, and L-thyroxine doses were unavailable, precluding stratified analysis. Fourth, FT4 was available in only 21 participants, not in controls, and assay units and reference intervals could not be independently verified. These limitations prevent firm interpretation of FT4 distributions and correlations.

Fifth, the retained dataset lacked a complete screening log, counts of exclusions for image quality, and some conventional echocardiographic measurements. Ultrasound-system and transducer identifiers, cycle averaging, formal blinding, tracking-quality criteria, and manual-correction procedures were not retained. LA strain was obtained from the apical four-chamber view only, and interobserver and intraobserver reproducibility were not assessed.

Finally, numerous group comparisons and correlations were conducted without adjustment for multiple testing. Secondary p values may therefore include false-positive findings. The study should be considered exploratory and the reported associations should be confirmed in larger, prospectively enrolled, age-matched cohorts using standardized thyroid phenotyping, biplane LA strain, reproducibility testing, and prespecified multiplicity control.

Conclusion.

Women with a documented history of treated or untreated overt or subclinical hypothyroidism showed unadjusted differences in RV free-wall strain and the magnitude of LA contractile strain compared with euthyroid controls. Hypothyroidism was not independently associated with LA contractile strain after adjustment for age, BMI, DBP, and heart rate. Because the cohort was heterogeneous, controls were older, and several biochemical and technical details were unavailable, the findings should be interpreted as exploratory associations rather than direct effects of thyroid dysfunction. Prospective, age-matched studies with standardized biochemical classification and echocardiographic acquisition are required.

Declarations.

Ethics approval and consent to participate: The source submission documented approval by a local institutional ethics

committee and written informed consent before the original evaluation. The research protocol was reviewed and approved by the Independent Local Ethics Committee of Tbilisi Medical Institute (Approval Date: 30 October 2023).

Conflict of interest: The authors declare no conflict of interest.

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Data availability: The de-identified analytic data underlying the reported tables are held by the study investigators. Availability is subject to institutional and ethical restrictions.

Artificial intelligence use: ChatGPT (OpenAI) was used for language editing, organization, and formatting. It was not used to collect data or perform the reported statistical analyses. The authors reviewed the manuscript and remain responsible for its scientific accuracy and integrity.

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ქართული რეზიუმე

კვლევის მიზანი: ჰიპოთირეოზის დოკუმენტირებული ანამნეზის მქონე ქალებსა და ეუთირეოიდულ საკონტროლო ჯგუფს შორის სტანდარტული და სპეკლ-ტრეკინგ ექოკარდიოგრაფიული მაჩვენებლების შედარება, მარცხენა წინაგულის კუმშვითი დეფორმაციის წინასწარ განსაზღვრული შეფასებით.

მასალა და მეთოდები: რეტროსპექტულ შემთხვევა-კონტროლის ანალიზში შევიდა 86 ქალი: 36 პაციენტი ადრე დოკუმენტირებული მანიფესტური ან სუბკლინიკური ჰიპოთირეოზით და 50 ეუთირეოიდული კონტროლი. ჰიპოთირეოზის ჯგუფი ჰეტეროგენული იყო და მოიცავდა როგორც ნამკურნალებ, ისე არანამკურნალებ მონაწილეებს; 31 (86,1%) იღებდა L-თიროქსინს. ჩატარდა სტანდარტული ტრანსთორაკალური და ორგანოზომილური სპეკლ-ტრეკინგ ექოკარდიოგრაფიული შეფასება. პირველადი გამოსავალი იყო მარცხენა წინაგულის კუმშვითი strain; დანარჩენი შედარებები იყო საძიებო. რეგრესიული მოდელი დაკორექტირდა ასაკის, სხეულის მასის ინდექსის, დიასტოლური წნევისა და გულისცემის მიხედვით.

შედეგები: ჰიპოთირეოზის ჯგუფი კონტროლებთან შედარებით ახალგაზრდა იყო. მარცხენა პარკუჭის განდევნის ფრაქცია ორივე ჯგუფში შენარჩუნებული იყო. არაკორექტირებულ ანალიზში გამოვლინდა მარჯვენა პარკუჭის თავისუფალი კედლის strain-ის

და მარცხენა წინაგულის კუმშვითი strain-ის სიდიდის შემცირება. კორექტირების შემდეგ ჰიპოთირეოზი დამოუკიდებლად არ იყო დაკავშირებული მარცხენა წინაგულის კუმშვით strain-თან ($p=0.057$), ხოლო გულისცემა დარჩა დამოუკიდებელ ფაქტორად ($p=0.017$).

დასკვნა: ჰეტეროგენულ ჰიპოთირეოზულ ჯგუფში გამოვლენილი არაკორექტირებული განსხვავებები არ ადასტურებს ჰიპოთირეოზის დამოუკიდებელ ეფექტს წინაგულის მექანიკაზე. საჭიროა საკითხეზე შეწყვილებული, პერსპექტიული კვლევები სტანდარტიზებული ბიოქიმიური კლასიფიკაციით.

საკვანძო სიტყვები: ჰიპოთირეოზი, სპეკლ-ტრეკინგ ექოკარდიოგრაფია, მარცხენა წინაგულის strain, მარჯვენა პარკუჭის strain

РЕЗЮМЕ

Цель: Сравнить стандартные и speckle-tracking эхокардиографические показатели у женщин с документированным анамнезом гипотиреоза и у эутиреоидных лиц контрольной группы, уделяя основное внимание заранее определённому показателю сократительной деформации левого предсердия.

Материал и методы: В ретроспективный анализ случай-контроль включены 86 женщин: 36 с ранее документированным явным или субклиническим гипотиреозом и 50 эутиреоидных участниц контрольной группы. Группа гипотиреоза была неоднородной и включала леченых и нелеченых участниц; 31 (86,1%) получала L-тироксин. Проведены стандартная трансторакальная и двухмерная speckle-tracking эхокардиография. Первичным исходом была сократительная деформация левого предсердия; остальные сравнения считались поисковыми. Регрессионная модель была скорректирована по возрасту, индексу массы тела, диастолическому артериальному давлению и частоте сердечных сокращений.

Результаты: Участницы с гипотиреозом были моложе контрольной группы. Фракция выброса левого желудочка сохранялась в обеих группах. В нескорректированном анализе выявлены меньшая по абсолютной величине деформация свободной стенки правого желудочка и сократительная деформация левого предсердия. После коррекции гипотиреоз не был независимо связан с сократительной деформацией левого предсердия ($p=0,057$), тогда как частота сердечных сокращений сохраняла независимую связь ($p=0,017$).

Выводы: Нескорректированные различия, выявленные в неоднородной группе гипотиреоза, не подтверждают независимое влияние гипотиреоза на механику левого предсердия. Необходимы проспективные исследования с сопоставлением по возрасту и стандартизированной биохимической классификацией.

Ключевые слова: гипотиреоз, speckle-tracking эхокардиография, деформация левого предсердия, деформация правого желудочка.