Echocardiographic screening for liver steatosis

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INTRODUCTION

Hepatic steatosis and its main cause— non-alcoholic fatty liver disease (NAFLD) is the most common hepatic abnormality, affecting about 30% of the adult population [1]. NAFLD is regarded as a hepatic manifestation of metabolic syndrome and often coexists with abdominal obesity, hypertension, diabetes or insulin resistance, and dyslipidemia [2]. Patients with fatty liver are at increased risk of developing both cardiovascular and hepatic complications, as well as hepatic and extrahepatic cancers [3].

Parts of the liver are frequently visualized during routine echocardiographic evaluation, especially from subcostal views. Increased brightness of liver tissue often reflects liver fat accumulation, however, using a reference point such as the right kidney cortex echogenicity is recommended.

In recent decades the hepato-renal index (HRI) emerged as a reliable screening tool for noninvasive, ultrasonographic evaluation of liver steatosis [4]. Using dedicated software, it compares numerical values of liver and right renal cortex brightness, assuming normal kidney function.

As the evaluation of fatty liver may be of potential clinical value in patients with cardiovascular diseases [5, 6], we decided to investigate the feasibility of echocardiography in diagnosing liver steatosis using the HRI, as well as direct visual assessment.

METHODS

We retrospectively analyzed liver and right kidney images registered during preoperative echocardiography in 224 consecutive patients with grade III obesity admitted for bariatric surgery to the Department of General, Transplant and Liver Surgery (Medical University of Warsaw, Poland) in the years 2016–2019 and 2022–2023. Echocardiography was performed in the Department of Internal Medicine, Hypertension and Vascular Diseases by a single cardiologist experienced in echocardiography. We included all patients admitted for laparoscopic sleeve gastrectomy. The exclusion criteria for our study were a history of chronic kidney disease, lack of right kidney, and inability to acquire adequate quality image containing the right renal cortex with adjacent liver parenchyma. Four patients were excluded from the analysis due to poor image quality.

The study protocol was reviewed and approved by the Ethics Committee of the Medical University of Warsaw (KB 117/2016). All participants provided written informed consent.

During echocardiography (GE Vivid 9) images of the renal cortex and adjacent liver parenchyma were acquired using a 1.7/3.3 MHz sector probe, from the right lateral approach in the supine position and stored on a dedicated workstation (GE Echopac). Then, single frames from recorded loops were chosen and saved in JPG format for further evaluation. Two echocardiographic presets, predefined by the producer, were used for image acquisition: general cardiologic and abdominal, both working with the second harmonic imaging technique (Supplementary material, *Figure S1*). Time gain compensation (TGC) keys were set in the neutral position.

The echogenicity of the liver parenchyma and kidney cortex was compared using free online software (Image J, US), measuring bri-

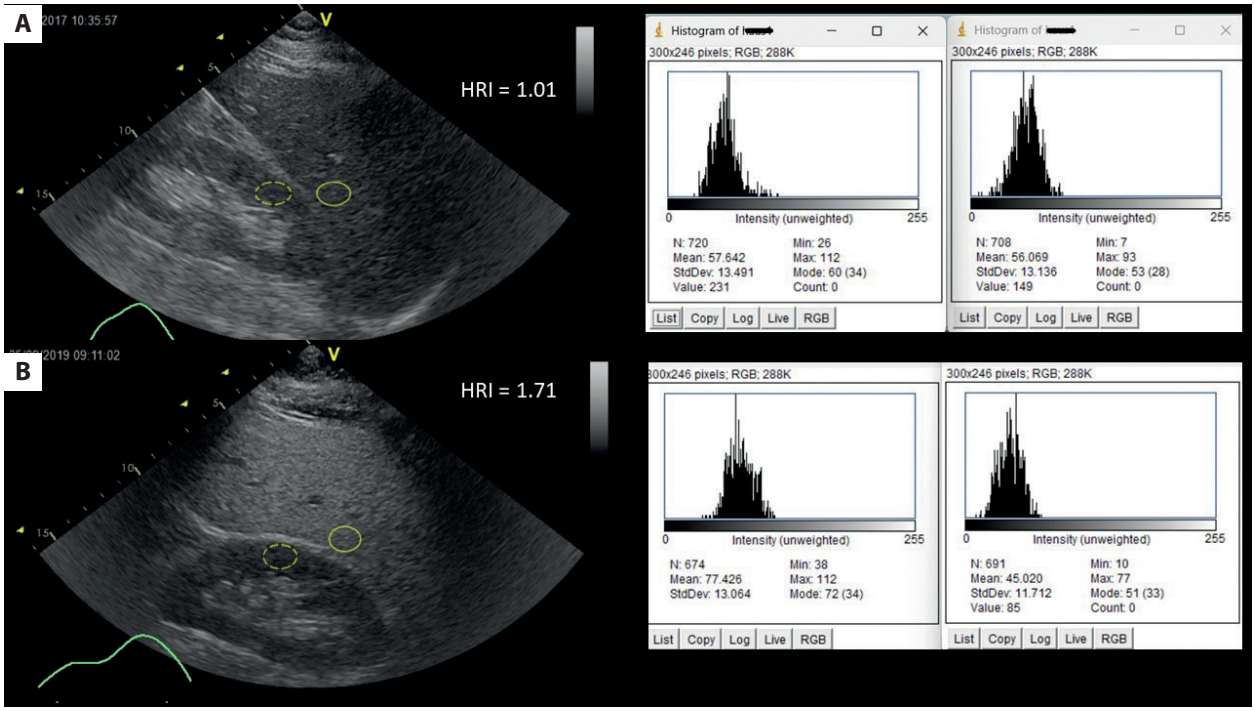

Figure 1. Grayscale image analysis for HRI calculation. **A.** Normal. **B.** Fatty liver

ghtness using greyscale analysis (Figure 1). The detailed method of measurement is described in the Supplementary material (*Appendix 1*).

Additionally, one observer experienced in echocardiography and two inexperienced observers (first-year residents in cardiology) performed direct visual analysis of recorded images. Increased brightness of liver tissue relative to the adjacent right kidney cortex was classified as the presence of steatosis, while similar brightness as lack of steatosis. Images were randomly divided into training (known degree of steatosis) and validation sets (blinded to the degree of steatosis), with a similar proportion of pictures with steatosis.

All patients underwent intraoperative wedge liver biopsy during surgery. Fatty liver was diagnosed if more than 5% of hepatocytes had steatosis (histopathologic examination).

Statistical analysis

The Shapiro–Wilk test was used to assess the normality of distribution of the variables. For continuous variables with normal and non-normal distribution, data were expressed as means and standard deviations and medians and interquartile ranges, respectively. Categorical data were presented as the number of cases in each category and percentages. Qualitative variables were compared using the χ^2 test and continuous variables using Student's t-test and the Mann–Whitney U test for normal and non-normal distribution, respectively. *P*–values <0.05 were considered statistically significant.

The area under the receiver operating characteristics curve (AUROC) was used to analyze the diagnostic accuracy of the HRI in detecting steatosis. First, AUROC was estimated on all images to compare the potential influence of the image acquisition mode (cardiac or abdominal preset) on HRI accuracy. The difference between AUROC was tested using Hanley's algorithm implemented in the statistical software. Next, the optimal cut-off value was determined by the Youden index in the randomly selected images from the training set and applied to the validation set to assess sensitivity, specificity, positive (PPV), and negative predictive value (NPV).

Spearman correlation analysis was performed to evaluate the correlation between the HRI and the grade of histological steatosis. Interobserver repeatability of HRI results was tested on randomly selected 50 images and expressed as intraclass correlation coefficient 2 (ICC2). In the validation set of images (n = 109) each observer's visual assessment of hepatic steatosis was compared with the biopsy results and sensitivity, specificity, NPV, and PPV were calculated. Interobserver agreement between the 3 observers on the visual diagnosis of liver steatosis was tested on 50 randomly selected images from the validation set and expressed as Cohen's kappa coefficient.

All computations were performed using STATISTICA 13.3 (TIBCO, US).

RESULTS AND DISCUSSION

Characteristics of the study patients are presented in Supplementary material (*Table S1*).

In the whole group, the ROC curve showed superior diagnostic accuracy of HRI in detecting steatosis on images acquired with abdominal preset compared to cardiac preset (AUC 0.887 vs. 0.857, respectively; $P = 0.009$) (Supple-

mentary material, *Figure S2*). Therefore, further evaluation was based on images acquired with the cardiac probe using the abdominal preset.

In the whole group (n = 220), the Spearman correlation coefficient between the HRI and the degree of steatosis was 0.68 (P <0.001) (Supplementary material, *Figure S3*).

In the training set of images (n = 111, 68% with steatosis), the ROC curve analysis showed an AUC of 0.879, with the optimal cut-off HRI value of 1.34 for the presence of steatosis (Supplementary material, *Figure S4*).

In the validation set (n = 109, 67% with steatosis), adapting this cut-off value resulted in 90% sensitivity, 81% specificity, 91% PPV, and 81% NPV for detecting steatosis. The interobserver variability of the HRI by ICC2 was 0.76.

Compared to liver biopsy, sensitivity, specificity, PPV, and NPV of the visual diagnosis of steatosis by the experienced observer were 88%, 77%, 89%, and 75%, respectively, and by inexperienced observers I and II: 96%, 57%, 82%, and 87%, and 87%, 81%, 92%, and 72%, respectively (Supplementary material, *Table S2*). Interobserver agreement on the visual diagnosis of hepatic steatosis assessed with Cohen's kappa coefficient was 0.6219 between the experienced and the inexperienced observer I, 0.8718 between the experienced and the inexperienced observer II, and 0.6018 between inexperienced observers.

We demonstrated that echocardiographic screening for liver steatosis is feasible, with a simple comparison of the brightness of the liver and renal cortex. Both methods, the HRI and visual evaluation, demonstrated acceptable diagnostic accuracy in patients with challenging visualization (grade III obesity).

Quick visual echocardiographic diagnosis of liver steatosis may potentially be clinically relevant for cardiologists performing echocardiography. It may add valuable information about the patient's metabolic status; it can also influence prognostic assessment and treatment of underlying cardiovascular disease. In cardiac patients without known metabolic disease, the presence of fatty liver is usually associated with insulin resistance, impaired glucose tolerance or diabetes, arterial hypertension, dyslipidemia, and/or alcohol overuse. Less common causes of hepatic steatosis include viral or autoimmune hepatitis, celiac disease, hypothyroidism, HIV infection, and drug-induced liver injury [7].

In the case of patients diagnosed with a metabolic disease, the presence of hepatic steatosis on follow-up may suggest suboptimal management of the underlying condition. Fatty liver is strongly associated with HbA1c levels [8]; therefore, inadequate diabetic control may result in persistent steatosis while effective treatment may decrease liver fat [9]. Weight reduction by 10%, as well as alcohol abstinence, may reverse liver steatosis [10], while continued drinking has been typically associated with fatty liver [11]. Alcohol-related steatosis is an important clinical finding, as it may be associated with arrhythmia, heart failure, or hypertension. Its diagnosis is straightforward with the history of excessive ethanol use; however, alcohol consumption is often underreported.

Limitations of this study are described in Supplementary material (Appendix 2).

In conclusion, echocardiographic screening for fatty liver using computerized and visual evaluation of the liver-to-kidney echogenicity ratio seems feasible, even for inexperienced observers. It may unveil the presence of an occult or inadequately treated metabolic disease, modify prognostic assessment, and help optimize treatment in patients with established cardiovascular diseases. However, further studies on clinical utility of this approach are needed.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/polish_heart_journal.

Article information

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