

Utility of ^{99m}Tc -sestamibi Heart/Liver uptake ratio in Screening Non-alcoholic Fatty Liver Disease during Myocardial Perfusion Imaging

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Research Article

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Abstract

Purpose

Non-alcoholic fatty liver disease (NAFLD) is the most common chronic hepatic disease worldwide with functional impairment of the mitochondria occurring from early stages. Technetium-99m methoxy-isobutyl-isonitrile (99mTc-MIBI) is a lipophilic agent trapped in the mitochondria. This study aims to evaluate the utility of 99mTc-MIBI heart/liver uptake ratio in screening for NAFLD during myocardial perfusion imaging (MPI).

Methods

70 eligible patients underwent a two-day rest/stress 99mTc-MIBI scan with a 2-minute planar image acquired in rest phase, at 30, 60 and 120 minutes post radiotracer administration. Heart/liver uptake ratio was calculated by placing identical regions of interest on the heart and liver dome. All patients underwent liver ultrasound and were allocated into groups A, having NAFLD, and B, healthy individuals without NAFLD.

Results

Mean count per pixel heart/liver ratios gradually increased over time in either groups; nonetheless the values were significantly higher in group A, regardless of acquisition timing; with the *P*-value equal to 0.007, 0.014 and 0.010 at 30, 60 and 120 minutes, respectively.

Conclusions

Determining 99mTc-MIBI heart/liver uptake ratio during rest phase in patients undergoing MPI may be a useful, non-invasive screening method for NAFLD; with no additional cost, radiation burden or adverse effects in these patients.

Lay Summary

- Functional impairment of the mitochondria causes decreased relative tissue uptake of Technetium-99m methoxy-isobutyl-isonitrile (99mTc-MIBI).
- Determining the relative liver uptake of 99mTc-MIBI during myocardial perfusion imaging may assist screening non-alcoholic fatty liver disease (NAFLD).
- Relative liver uptake of 99mTc-MIBI is significantly lower in NAFLD patients, regardless of measurement time.

Introduction

Significantly correlated with metabolic syndrome, non-alcoholic fatty liver disease (NAFLD) has become a global “pandemic” with increasing prevalence, affecting about 24.1% of the population. This umbrella term covers a wide spectrum of conditions, from simple hepatic steatosis to non-alcoholic steatohepatitis (NASH), with presence of inflammation and hepatocyte damage (steatohepatitis), ultimately leading to cirrhosis +/- hepatocellular carcinoma in most severe cases [1, 2]. NAFLD is associated with atherogenic dyslipidaemia and an increased cardiovascular risk [3], with cardiovascular disease being the leading cause of death in these patients [4]. While liver biopsy remains the gold standard method of diagnosis, there is growing interest in implementing non-invasive diagnostic

modalities, such as liver ultrasound and magnetic resonance spectroscopy (MRS), with the former currently recommended as the first-line screening modality in selected populations [5]. Despite all, NAFLD remains an underdiagnosed condition and is generally underappreciated by primary health care physicians [6]. Myocardial perfusion imaging (MPI) with Technetium-99m methoxy-isobutyl-isonitrile (99mTc-MIBI) is a mainstay modality in diagnosis and management of coronary artery disease, as a non-invasive, accessible, cost-effective modality with relatively low radiation burden. 99mTc-MIBI is a lipophilic cationic agent, predominantly retaining in the mitochondria, because of their significantly negative transmembrane potential. Therefore, it is also being implemented in assessing the mitochondrial metabolic impairment and oxidative stress in various other mitochondrial diseases and neurodegenerative disorders [7, 8]. Responsible for fatty acid oxidation, structural and molecular alterations of mitochondria has a pivotal role in the pathogenesis of NAFLD. Mitochondrial function impairment occurs from the early stages of hepatic steatosis, gradually leading to oxidative stress and inflammation, eventually resulting in apoptosis of hepatocytes and fibrotic changes [9, 10]. Considering the independent risk NAFLD poses for coronary artery disease (CAD), as well as the significant correlation both have with metabolic syndrome; NAFLD is expected to be more prevalent in candidates for MPI scan [3, 4]. This study aims to evaluate the potential role of determining the relative hepatic uptake of 99mTc-MIBI during rest phase MPI in screening NAFLD in patients referred for ruling out myocardial ischemia; thereby, facilitating its early diagnosis and treatment.

Material And Methods

Patient Selection And Allocation

This study was approved by the Clinical Research Ethics Committee of the Medical School of Shahid Beheshti Medical University (IR.SBMU.MSP.REC.1398.308). All procedures involving human participants were carried out in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All patients were interviewed by a nuclear medicine physician and were thoroughly informed about the methods and objectives of this study. Eligible patients were included only after having their oral and written informed consent documented.

This prospective, single-center study compromised 70 eligible patients who were referred for 99mTc-MIBI MPI to rule out myocardial ischemia during a period of 6 months. Patients with any documented cardiac disease, patients with high pre-test probability of ischemic heart disease (IHD), patients with history of diabetes mellitus, regular alcohol consumption (>20 g per day), benign or malignant hepatic neoplasm, any kind of viral, metabolic or autoimmune liver disease as well as patients taking any hepatic steatosis-inducing medications (such as corticosteroids, Methotrexate, Tamoxifen and insulin), were not included in the study. 197 patients with low to intermediate/intermediate pre-test probability of IHD, who were referred for MPI to rule out myocardial ischemia, underwent a two-day rest/stress 99mTc-MIBI gated single photon emission computed tomography (SPECT), from whom 127 patients with abnormal myocardial perfusion or significant soft tissue attenuation effects, defined as summed stress score (SSS) or summed rest score (SRS) > 2, were excluded from the study. Acquisition details will be discussed in the following section. The remaining 70 participants had their body mass index (BMI = Height/Weight²) documented and underwent peripheral venous blood sampling, after a 9-hour fasting, to check their biochemical profile and liver function tests (LFT); including fasting blood sugar (FBS), triglyceride (TG), Total Cholesterol, aspartate aminotransferase (AST), alanine aminotransferase (ALT), Albumin (Alb) and prothrombin time (PT). All patients underwent liver ultrasound examination, according to which were allocated into group A,

patients with any degree of fatty liver disease, and group B, patients with normal results having no evidence of fatty liver disease.

Acquisition Protocols And Image Processing

All patients underwent a two-day rest/stress ^{99m}Tc -MIBI gated SPECT MPI, according to the European Association of Nuclear Medicine guidelines for MPI scan [7]. All ^{99m}Tc -MIBI kits underwent thin layer chromatography and radiochemical purity > 95% was deemed acceptable for utilization. Following IV injection of 555 MBq ^{99m}Tc -sestamibi, a 2-minute planar image of the thoraco-abdominal region was acquired at 30, 60 and 120 minutes, in anterior view, with the patient lying supine. The standard rest SPECT was acquired, as per usual, at 60 minutes post-injection. On the day after, myocardial stress was achieved by exercise (Bruce protocol) or Dipyridamole injection (0.14mg/kg/min over 4 minutes), with 740 MBq ^{99m}Tc -sestamibi injected at peak stress and acquisition performed as per routine. All patients took 120 cc of whole milk 10 minutes after each tracer injection. Images were acquired with a variable angle dual head Evo-Voxel Siemens gamma camera with low-energy high resolution collimator, 140 Kev photopeak setting, symmetrical width energy window of 10%, matrix 64 * 64 and zoom of 1.46; including the rest planar image (2 minute duration, anterior view) and standard SPECT images (64 projections; 25 seconds/projection, 8-frame gated study, non-circular orbit). Images were processed by a nuclear medicine physician, blinded to patient allocations, using quantitative perfusion SPECT (QPS) (Fig. 1) and quantitative gated SPECT (QGS) software (Cedars-Sinai Medical Center Cardiac Suite). As described above, patients with abnormal myocardial perfusion or significant soft tissue attenuation effects, defined as summed stress score (SSS) or summed rest score (SRS) > 2, were excluded from the study. Hand-drawn regions of interest (ROI) were set on the each planar rest image (3 images per person at 30, 60 and 120 minutes), with identical size and shape ROIs placed on the upper segments of right liver lobe as well as anterolateral wall of the left ventricle, to minimize the interfering effects (such as scatter) of these adjacent organs (Fig. 2). The mean count per pixel values were obtained and the heart to liver ratios calculated, which considering that we had excluded patients with any cardiac disease or abnormal MPI results, would be an indicator of relative hepatic uptake.

Statistical Analysis

Quantitative and categorical or qualitative data were represented by the mean, standard deviation (SD) and numbers/percentages, respectively. We used the Kolmogorov-Smirnov test for the assessment of the normality of distribution. Mann-Whitney *U*-test was utilized to determine the statistical differences between two groups of normal and NAFLD patients. *P*-value < 0.05 was considered significant. Random forest classifier with 5-fold cross validation was used to develop a model based on clinical and scintigraphy findings to predict NAFLD, by implementing three different strategies (Scheme: `weka.classifiers.trees.RandomForest -P 100 -I 100 -num-slots 1 -K 0 -M 1.0 -V 0.001 -S 1`). Area under the receiver operating characteristic curve (AUROC) was selected as the assessment criterion.

Results

70 patients, consisting of 24 males (34.3%) and 46 females (65.7%), with the mean age of 51.0 ± 9.0 years; were categorized into groups A, having evidence of fatty liver disease ($n = 30$); and B, with normal liver ($n = 40$). The demographic, clinical and laboratory characteristics of the participants are presented in Table 1. Age, gender and liver function test results (including AST, ALT, serum Alb and PT) had no statistically significant difference among

the groups (P -value > 0.05). As expected, BMI, TG and total cholesterol levels were significantly higher in group A (P -value = 0.000).

Table 1
Baseline characteristics of all patients (n = 70)

	Group A (n = 30)	Group B (n = 40)	P-value
Age (years)	52.8 +/- 1.4	49.6 +/- 9.6	.125
Sex			.516
Female (%) (n)	(70%)(21)	(62.5%) (25)	
Male (%) (n)	(30%)(9)	(37.5%) (15)	
BMI (Kg/M ²)	31.5 +/- 0.8	25.9 +/- 3.3	.000
FBS (mg/dL)	118.0 +/- 8.2	104.8 +/- 34.4	.206
TG (mg/dL)	222.5 +/- 11.2	152.8 +/- 34.5	.000
Total Cholesterol (mg/dL)	218.0 +/- 7.1	159.7 +/- 41.9	.000
AST (IU/L)	23.7 +/- 1.7	19.8 +/- 6.0	.061
ALT (IU/L)	27.6 +/- 2.5	21.2 +/- 7.1	.064
Alb (g/dL)	4.0 +/- 0.1	4.0 +/- 0.6	.837
PT (s)	13.0 +/- 0.1	12.9 +/- 0.7	.110

Regarding the intrahepatic ^{99m}Tc-MIBI uptake, the mean count per pixel heart/liver ratios gradually increased over time in either groups; nonetheless the values were significantly higher in group A, regardless of acquisition timing; with the P -value equal to 0.007, 0.014 and 0.010 at 30, 60 and 120 minutes, respectively (Table 2).

Table 2
Heart/Liver uptake ratio in two groups of patients at three time points

	Group A Mean Rank (Mean +/- SD)	Group B Mean Rank (Mean +/- SD)	P-value
Heart/Liver Ratio at 30 min	43.07 (0.87 +/- 0.39)	29.83 (0.70 +/- 0.26)	.007
Heart/Liver Ratio at 60 min	42.40 (1.21 +/- 0.56)	30.33 (0.96 +/- 0.38)	.014
Heart/Liver Ratio at 120 min	42.73 (1.92 +/- 0.67)	30.08 (1.48 +/- 0.62)	.010

As for random forest classifier results (Table 3), the first strategy implemented all available para-clinical, demographic (age, sex, BMI) and scintigraphy (0.5, 1, and 2hr) data (true positive rate = 0.87, false positive rate = 0.15, precision = 0.88, AUROC = 0.95). The second strategy compromised lipid profile (TG, Cholesterol), FBS, demographic (age, sex, BMI) and scintigraphy (0.5, 1, and 2hr) data and demonstrated similar accuracy to the first strategy without including AST, ALT, Alb and PT (true positive rate = 0.86, false positive rate = 0.17, precision = 0.86, AUROC = 0.95). The third strategy only accounted for demographic (age, sex, BMI) and scintigraphy (0.5, 1, and 2hr) data to predict NAFLD (true positive rate = 0.76, false positive rate = 0.27, precision = 0.76, AUROC = 0.84). Repeating the third strategy by including single time point scintigraphy data at 1 hr. resulted in AUROC of 0.85,

comparable to the accuracy of multiple time point measurement. Heart/liver uptake ratios higher than the threshold of 1.0, at 1 hour post radiotracer injection, warrant further evaluation for potential NAFLD (Fig. 3).

Table 3
Random forest classifier results comparing the accuracy of different models in predicting NAFLD

Strategy	Sex	Age	BMI	BS	TG	Chol	AST	ALT	Alb	PT	H/L Ratio at 0.5 hr.	H/L Ratio at 1 hr.	H/L Ratio at 2 hr.	AUC
S1	*	*	*	*	*	*	*	*	*	*	*	*	*	0.95
S2	*	*	*	*	*	*					*	*	*	0.95
S3	*	*	*								*	*	*	0.84
S3-1 hr.	*	*	*									*		0.85

Discussion

NAFLD is the leading cause of chronic liver disease worldwide with its growing prevalence paralleling increasing cases of metabolic syndrome. While early stages of hepatic steatosis may be quite benign, it may progress to NASH and eventually cirrhosis [1–6]. Most cases will not develop high-grade NASH and cirrhosis; however, given its high prevalence, even small percentages translate to significant numbers. Pharmacologic treatment of NAFLD, specifically NASH-related fibrosis, is under extensive research; nonetheless, risk factor modification in early stages and preventing further progression remains the most appropriate measure. Therefore, developing non-invasive, accessible, simple methods of screening and diagnosis is of utmost importance. Liver biopsy remains the gold standard of diagnosis, unsuitable for screening due its invasive nature, potential complications and cost. Serum biomarkers have proven to significantly underestimate presence of NAFLD. The most commonly implemented radiologic methods are ultrasound and magnetic resonance spectroscopy (MRS); however, the cost-effectiveness of screening the general population by them is still under debate [11]. Our study indicates that rest phase heart/liver uptake ratio of ^{99m}Tc-MIBI is significantly higher in patients with NAFLD; proposing it as a simple screening method in patients already undergoing MPI to rule out myocardial ischemia, who are at a higher risk for NAFLD as well, with no additional cost, radiation burden or complication.

As expected we observed a gradual rise in Heart/Liver ratios in either groups, which is explained by the physiologic clearance of ^{99m}Tc-MIBI from the liver [12]. NAFLD patients demonstrated significantly higher Heart/Liver ratios, regardless of measuring time, including 1 hour post injection, which is the usual time point when rest phase acquisition is performed. Our findings are in accordance with findings of Masuda K et al, who evaluated 26 patients with biopsy-proven NAFLD by performing laboratory tests and a ^{99m}Tc-MIBI liver scintigraphy. They acquired a 2 minute planar image of thoraco-abdominal region in anterior view, 10 minutes after bolus injection of 600 MBq ^{99m}Tc-MIBI in rest phase. Mean count per pixel liver/heart ratios were calculated by defining ROIs in the right upper lobe of liver and the heart. They categorized the patients into non-NASH/simple hepatic steatosis (n=4), borderline NASH (n=11) and NASH (n=11) and reported that the relative hepatic uptake was significantly lower in NASH and borderline NASH compared to the non-NASH group, also compared to the healthy population (based on existing literature) and observed a significant correlation between the liver/heart ratio and degree of NASH [13]. Aside the small number of patients and not having a control group with the same exclusion criteria, a prominent limitation of this study is that the effect of cardiac uptake, which may be significantly reduced in patients with CAD and other

cardiomyopathies, is not accounted for, as the patients did not undergo a stress phase MPI scan [13, 14]. ^{99m}Tc-MIBI uptake portrays the mitochondrial function of cells [8] and NAFLD has been established as a disease of the mitochondria, with functional alterations of the mitochondria present even in the early stages of hepatic steatosis. These functional alterations lead to gradual impairment of fatty acid oxidation, resulting in oxidative stress and in turn leading to inflammation (NASH), hepatocyte apoptosis and fibrosis in advanced stages [9, 10], justifying the observed decreased hepatic uptake of ^{99m}Tc-MIBI in NAFLD patients compared to healthy individuals and possibly a correlation between relative uptake ratio and disease severity.

We developed a model to predict NAFLD based on patient's demographic, laboratory and scintigraphy (at 0.5, 1 and 2 hrs.) data. The model's strength while excluding laboratory data, which may not be always available, decreases to 0.84 AUROC, which is still sufficient enough for a screening tool. Employing single time point scintigraphy measurement results at 1 hour post tracer injection, the time rest phase MPI acquisitions usually take place, yields a comparable accuracy (AUROC = 0.85), alleviating the need for multiple acquisitions, with heart/liver uptake ratios higher than the threshold of 1.0 warranting evaluation for potential NAFLD (Fig. 3). Naturally, implementing the model in larger populations with result in a more accurate threshold. Several studies have focused on evaluation and comparison of the diagnostic performance of non-invasive methods for screening NAFLD. Brill et al, evaluated the accuracy of liver ultrasound for the diagnosis of nonalcoholic fatty liver disease in overweight and obese patients. They found performance of US (parenchymal echo alone) rather modest, and significantly worse than MRS (AUROC: 0.82 [0.69–0.94] vs. 0.96 [0.90–1.00]; P = 0.04). Implementing echography parameters improved the AUROC (0.89 [0.83–0.96]) [15]. Another study assessed the accuracy of hepatic ultrasound score, based on hepatic attenuation and the anteroposterior diameter of the right hepatic lobe, in predicting NAFLD. Its best performance (cutoff point ≥ 1 point) had AUROC of 0.85 [16]. The results were less favorable in children, at optimum screening cut-points aiming for a specificity $\geq 80\%$, US had only mediocre performance with AUROC of 0.70 [17]. Fatty liver index (FLI), NAFLD liver fat score (NAFLD-LFS), hepatic steatosis index (HSI), visceral adiposity index (VAI), triglyceride \times glucose (TyG) index and Zhejiang University (ZJU) index are noninvasive and non-imaging indexes, based on a complex list of laboratory data, employed to predict NAFLD [18, 19]. The AUROCs of FLI, LFS, HSI, VAI and TyG for predicting hepatic steatosis has been determined 0.83, 0.80, 0.81, 0.92 and 0.9; respectively. However, they had relatively poor performance in distinguishing moderate and severe steatosis, with fibrosis and inflammation identified as significant confounding factors [18]. Another study evaluated HSI, ZJU index and FLI for predicting NAFLD, with their AUROC determined 0.874, 0.886, and 0.884, respectively [19]. Considering all these data, the accuracy of our scintigraphy-based model for predicting NAFLD (AUROC of 0.85) is acceptable and comparable to other commonly used US and laboratory-based indexes. Of course, we are not implying it as an independent screening method competing with liver ultrasound; but when applied in patients already undergoing MPI to rule out myocardial ischemia, it has the prominent advantage of it being a secondary finding of MPI, with no additional cost, radiation burden or side-effect.

Our study demonstrated no significant difference in age, gender distribution, AST, ALT, serum Albumin and PT levels among the groups; while BMI, TG and total cholesterol levels were expectedly higher in NAFLD patients. These findings are in line with existing literature as liver function tests are proven to be neither sensitive nor specific in screening for NAFLD and are normal in about 50% of NAFLD patients [20, 21]. On the other hand hyperlipidemia is reported to be significantly associated with NAFLD. Nakahara et al, reported hyper-LDL cholesterolemia and hypo-HDL cholesterolemia in 37.5 and 19.5% of biopsy-proven NAFLD patients [22] and another study has determined TG as the strongest predictor of NAFLD among other parameters [23].

Study Limitations

This study has some limitations that should be considered. While liver ultrasound is currently recommended as the first line screening method for NAFLD; liver biopsy remains the gold standard of diagnosis, despite being rarely performed for this sole purpose. Regarding its invasive nature, possible complications and significant cost, acquiring pathological correlation for all included patients in this study was not feasible, nor ethical. The relatively small number of patients as well as limited accuracy of ultrasound did not allow us to further categorize NAFLD patients based grade of disease. To prevent the interfering effect of possibly reduced hepatic uptake and rest phase myocardial activity on relative hepatic uptake ratios, both due to micro-vascular disease, diabetic patients were excluded from the study. Whether similar results would be obtained in these excluded patients should be assessed in future studies. To ensure better signal to noise ratios, the relative hepatic uptake was calculated on an additional 2-minute planar acquisition, future studies are required to assess the feasibility of using the routine SPECT projections, omitting the need for additional acquisitions, for this measurement.

New Knowledge Gained

The main novelties of our manuscript are the following:

1. To our knowledge, this is the first study which assessed the feasibility of determining relative hepatic uptake of ^{99m}Tc -MIBI during rest phase MPI scan in screening patients for NAFLD, alongside evaluating the effect of different acquisition timings on the results.
2. To our knowledge, this is the first study which developed a model to predict NAFLD during MPI, based on patient's demographic, laboratory and multiple time point scintigraphy data
3. In comparison with the single reported previous study addressing this matter, comparing relative hepatic uptake of ^{99m}Tc -MIBI in steatohepatitis versus simple hepatic steatosis, our study compromised a significantly larger population including a control group, enabling assessing the value of relative ^{99m}Tc -MIBI hepatic uptake as a screening tool in differentiating NAFLD (regardless of degree) from non-NAFLD patients. Also, our study was performed in MPI setting with all participants undergoing stress phase as well, including only patients with normal myocardial perfusion. Therefore, the interfering effect of possibly reduced myocardial uptake due to any simultaneous cardiomyopathy was accounted for and the results could be attributed to routine MPI studies.

Conclusion

With regard to the independent risk NAFLD poses for CAD as well as the significant correlation both have with metabolic syndrome; NAFLD may be more prevalent in candidates for MPI scan. Calculating rest phase ^{99m}Tc -sestamibi Heart/Liver uptake ratio in patients who have been referred for MPI scan to rule out myocardial ischemia may be implemented as a feasible screening tool for NAFLD with an acceptable accuracy, comparable to several other non-invasive US or laboratory-based screening methods, warranting further evaluation of the patient. While not a competing rival against liver ultrasound, as the first line screening method for NAFLD; being a secondary finding of MPI scan in patients referred for ruling out myocardial ischemia, gives it the prominent advantage of having no additional cost, radiation burden or adverse effect.

Declarations

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Conflict of Interest: Authors, Ghazal Norouzi, Sara Nikdel, Elahe Pirayesh, Yazdan Salimi, Mahasti Amoui, Hamidreza Haghighatkah, Mohammad Ali Ghodsi Rad, Elmira Javanijouni and Sepideh Khoshbakht have no conflict of interest to disclose.

Ethics Approval Statement: This study was approved by the Clinical Research Ethics Committee of the Medical School of Shahid Beheshti Medical University (Trial registration number: IR.SBMU.MSP.REC.1398.308). All procedures involving human participants were carried out in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards (IR.SBMU.MSP.REC.1398.308). This article does not contain any experiments with animals.

Patient Consent Statement: All patients were thoroughly informed about the method and aims of this study. Written informed consent was obtained from all participants prior to inclusion in the study.

Permission to Reproduce Material from Other Sources: Not applicable.

Author Contribution: All authors have made substantial contributions to conception, design as well as acquisition of patients data; have been involved in drafting and revising the manuscript; have given final approval of the version to be published with each of them having participated sufficiently in the work to take public responsibility for appropriate portions of the content; and have agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Figures

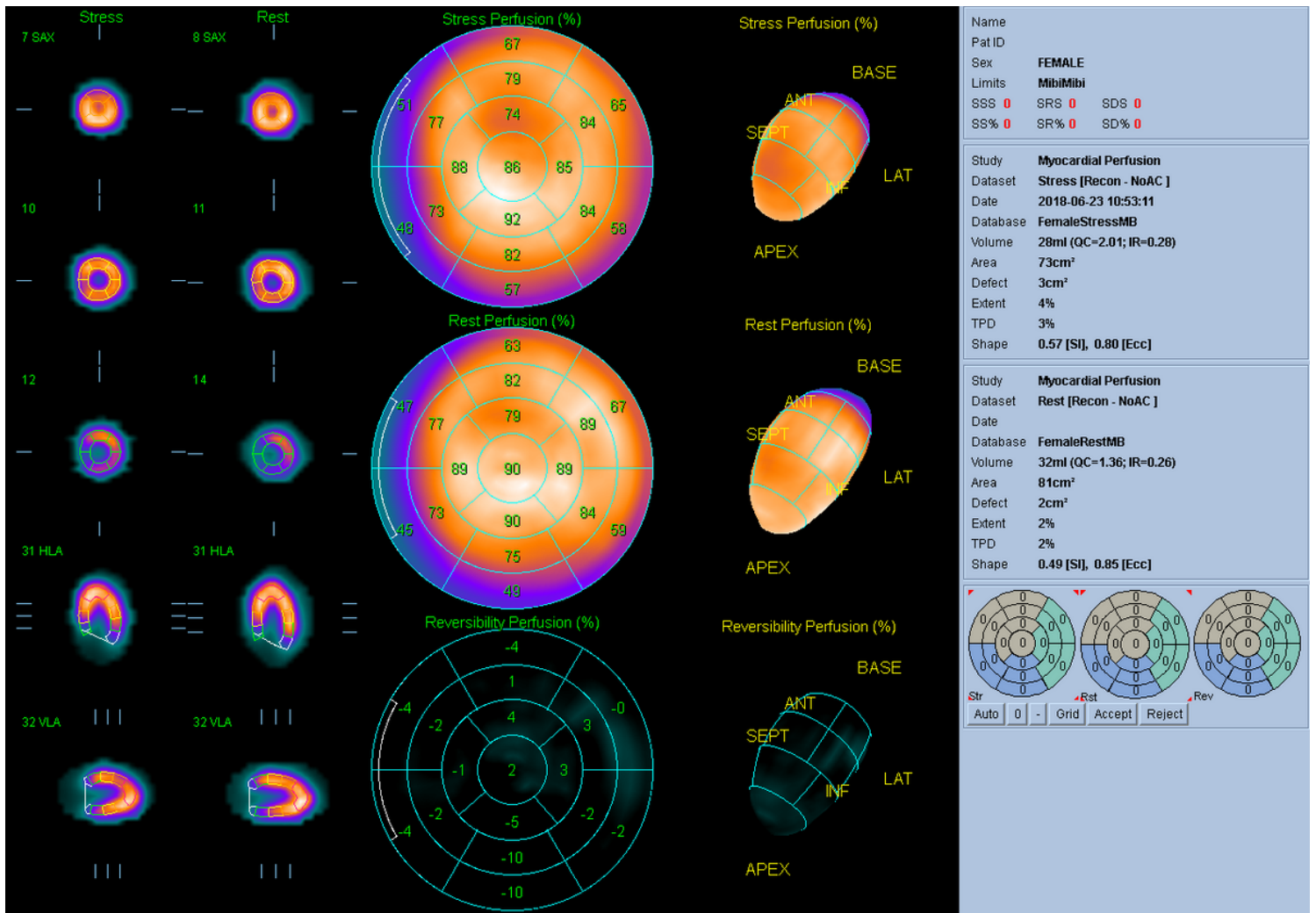


Figure 1

Quantitative Perfusion SPECT (QPS) (Cedars-Sinai Medical Center Cardiac Suite) enables automated quantification of perfusion defects during myocardial perfusion imaging. It divides the left ventricle into 17 standard segments and compares the registered counts in each segment with a normal population database. Scores are applied to each segment based on severity of the perfusion defect; 0, 1, 2, 3 and 4 indicate no defect, mild, moderate, severe defects and absence of perfusion, respectively. The summed stress/rest score, sum scores of all segments, is used in assessing global left ventricle ischemia. Summed scores < 4 are usually non-significant, often produced by soft tissue attenuation effects of breasts or the diaphragm. Patients with a summed stress or rest score of > 2 were excluded from this study

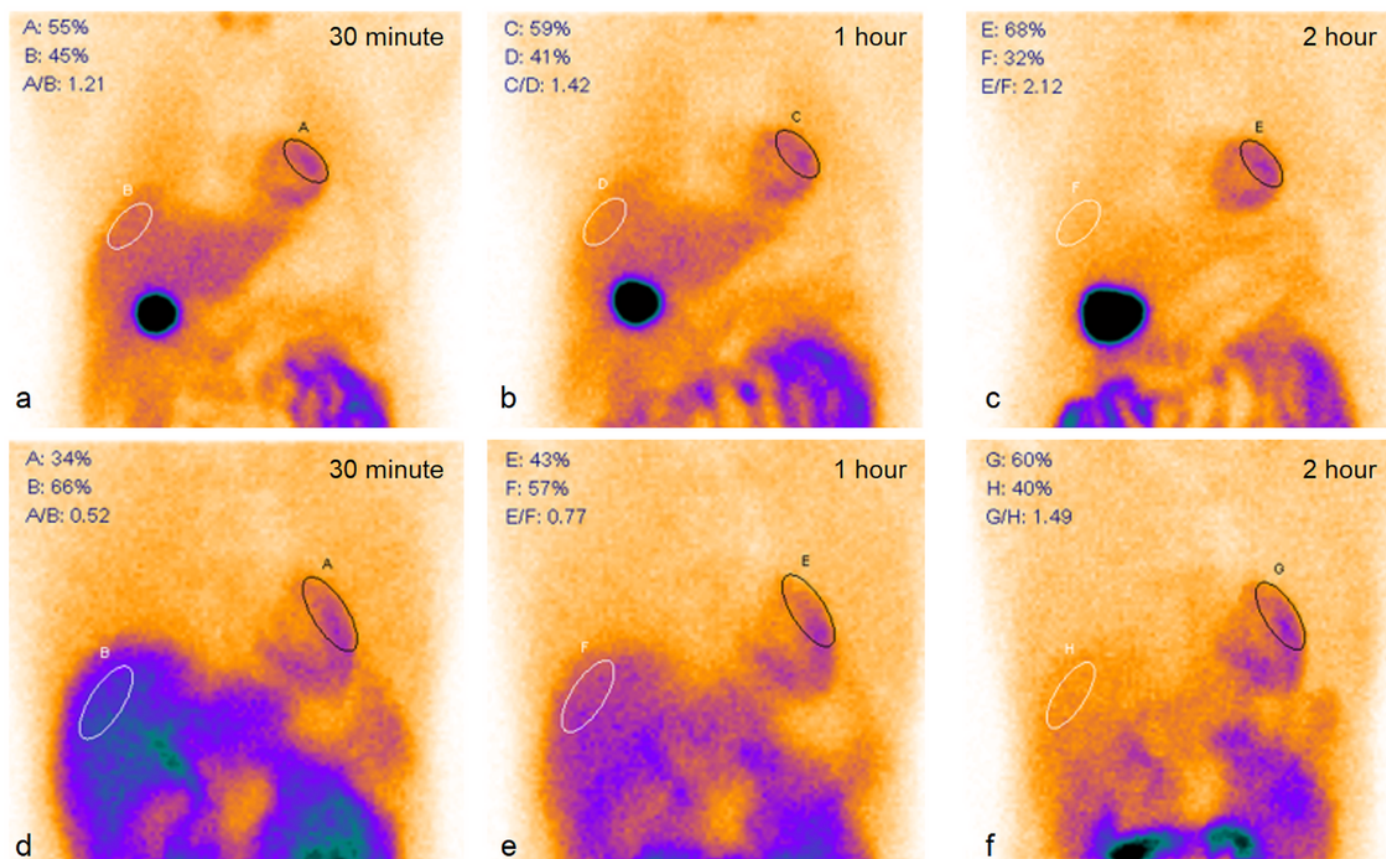


Figure 2

2-minute planar images of the thoraco-abdominal region were acquired after IV administration of 555 MBq ^{99m}Tc -MIBI at 30, 60 and 120 minutes, in anterior view. Identical size and shape region of interests were placed on the upper segments of right liver lobe as well as anterolateral wall of the left ventricle. Heart to liver ratios were calculated based on mean count per pixel values. Acquisitions a-c belong to a patient with NAFLD (from group A) and d-f to a normal patient (from group B)

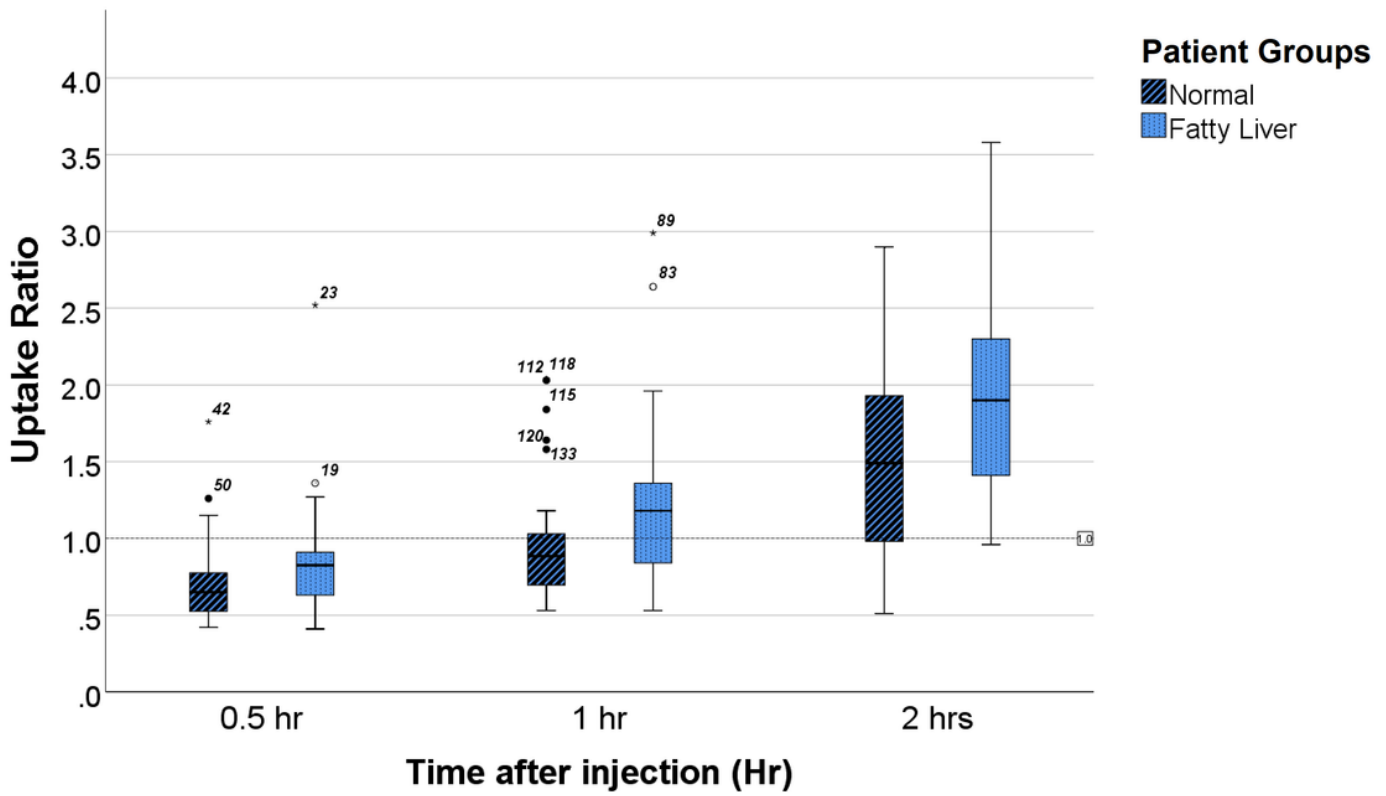


Figure 3

Comparison of the Heart/Liver uptake ratio in two groups of patients at three time points

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [RandomForestClassifierStatisticalAnalysis.rar](#)