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The combined effects of ursodesoxycholic acid and quercetin on liver health and cardiac function in patients with non-alcoholic fatty liver disease and atrial fibrillation

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Non-alcoholic fatty liver disease (NAFLD) or due modern nomenclature – metabolic dysfunction-associated steatotic liver disease (MASLD) and atrial fibrillation are interconnected health problems that require reassessment of treatment strategies to address their common underlying causes. Lifestyle changes and pharmacotherapy are used to manage NAFLD, while treatment for atrial fibrillation focuses on anticoagulation and rhythm control.

Aim. To evaluate the efficacy of combining ursodesoxycholic acid and quercetin with standard treatment to improve liver health and heart function in patients with non-alcoholic fatty liver disease and atrial fibrillation.

Material and methods. A prospective, randomized controlled trial was conducted on patients with NAFLD and atrial fibrillation at two hospitals from January 2020 to December 2023. The study involved 127 patients who were divided into three groups: standard treatment, standard treatment + ursodesoxycholic acid (UDCA), and standard treatment + UDCA + quercetin.

Results. The average age and sex distribution were similar among the three groups, suggesting that the randomization process successfully balanced the demographic characteristics. Paroxysmal atrial fibrillation was the most common form in all groups, followed by persistent atrial fibrillation and permanent atrial fibrillation, with no statistically significant differences between the groups. The body mass index was comparable across all three groups as well. The results showed a decrease in liver stiffness in all groups, with groups 2 and 3 showing the most significant improvements. Fibrosis stages also shifted after treatment, with group 3 showing a marked reduction in progressive fibrosis. Groups 2 and 3 also showed significant reductions in steatosis levels, with an increase in the proportion of patients without steatosis. Left atrial diameter decreased in all groups, with group 3 showing the most significant reduction. Left ventricular ejection fraction improved in all groups, with the most significant increase in group 3. Group 3 also showed improvements in diastolic filling and left ventricular filling pressure. Overall, the combined treatment regimen in group 3 appeared to have the most favourable effects on liver and cardiac health.

Conclusions. The addition of UDCA and quercetin to standard treatment regimens for NAFLD and atrial fibrillation shows promising improvements in liver health and cardiac function.

Ключові слова: неалкогольна жирова хвороба печінки, фібриляція передсердь, кверцетин, урсодезоксихолева кислота, міокард.

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Комбінований вплив урсодезоксихолевої кислоти та кверцетину на структуру печінки та серцеву функцію в пацієнтів із неалкогольною жировою хворобою печінки та фібриляцією передсердь

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Неалкогольна жирова хвороба печінки (НАЖХП) та фібриляція передсердь – взаємопов'язані проблеми, що потребують специфічних стратегій лікування для усунення спільних патогенетичних ланок. В основі лікування НАЖХП – зміна способу життя та корекція маси тіла, а менеджмент фібриляції передсердь фокусується передусім на антикоагуляції та контролі ритму.

Мета роботи – оцінити ефективність поєднання урсодезоксихолевої кислоти та кверцетину зі стандартною терапією для покращення стану печінки та серцевої функції в пацієнтів із НАЖХП і фібриляцією передсердь.

Матеріали і методи. Проспективне, рандомізоване контрольоване дослідження здійснили за участю пацієнтів із НАЖХП і фібриляцією передсердь у двох лікарнях з січня 2020 до грудня 2023 року. До дослідження залучили 127 пацієнтів, яких поділили на три групи залежно від терапії, яку вони одержали: стандартне лікування, стандартне лікування + урсодезоксихолева кислота (УДХК) та стандартне лікування + УДХК + кверцетин.

Результати. Розподіл за віком і статтю статистично однорідний у трьох групах обстежених. Це свідчить, що процес рандомізації успішно збалансував демографічні характеристики. Пароксизмальна форма фібриляції передсердь найпоширеніша в усіх групах, далі – персистуюча та постійна форми фібриляції передсердь, без статистично значущих відмінностей між групами. У результаті дослідження виявили зменшення фіброзу печінки в усіх групах, й у групах 2 і 3 визначено найістотніше вірогідне зменшення. Стадії фіброзу також змінилися після лікування; у групі 3 встановлено вірогідне зменшення прогресивної форми фіброзу. У групах 2 і 3 визначили істотне зниження рівня стеатозу, а також збільшилася частка пацієнтів без стеатозу. Діаметр лівого передсердя зменшився в усіх групах, у групі 3 зафіксовано найбільш значуще зменшення. Фракція викиду лівого шлуночка покращилася в усіх групах, найістотніше збільшення – у групі 3. У цій групі зафіксовано покращення діастолічного наповнення та тиску наповнення лівого шлуночка. Загалом комбінована схема лікування в групі 3 мала найсприятливіший вплив на структурно-функціональні параметри печінки та серця.

Висновки. Додавання УДХК і кверцетину до стандартних схем лікування НАЖХП і фібриляції передсердь сприяє покращенню структурно-функціональних параметрів печінки та серця.

Non-alcoholic fatty liver disease (NAFLD) or due modern nomenclature – metabolic dysfunction-associated steatotic liver disease (MASLD) is a significant global health concern and the leading cause of chronic liver disease in the 21st century [1]. It is characterized by the accumulation of fat in liver cells in individuals who consume little to no alcohol. The prevalence of NAFLD is estimated to affect approximately 32.4 % of the global population, indicating a silent epidemic [2]. The disease spectrum associated with NAFLD ranges from simple steatosis, which is largely benign, to non-alcoholic steatohepatitis (NASH), a more aggressive form that may progress to cirrhosis, liver failure, or hepatocellular carcinoma. The pathogenesis of NAFLD is intricately linked to insulin resistance, which is a hallmark of metabolic syndrome. These associations underscore the systemic nature of NAFLD, emphasizing its position at the intersection of metabolic dysregulation[3].

In addition to the rising prevalence of NAFLD, atrial fibrillation, the most prevalent sustained cardiac arrhythmia, presents significant public health challenges [4]. Affecting millions globally, atrial fibrillation is a major risk factor for stroke, heart failure, and systemic embolism, contributing significantly to morbidity, mortality, and healthcare costs. The pathophysiological basis of atrial fibrillation involves structural and electrical changes in the atria, which are triggered by conditions such as hypertension, coronary artery disease, and valvular heart disease [5]. Moreover, recent research has uncovered a new association between NAFLD and atrial fibrillation, suggesting that the metabolic and inflammatory environment of NAFLD may heighten the risk of developing atrial arrhythmias. The evidence suggests a complex relationship between metabolic liver disease and cardiac arrhythmia [6]. Therefore, it may be necessary to reevaluate treatment strategies that address these interconnected pathologies.

The current management of NAFLD focuses on lifestyle interventions aimed at weight reduction and metabolic control, with pharmacotherapy primarily reserved for those with NASH or fibrosis [7]. Ursodesoxycholic acid (UDCA), although not specifically approved for NAFLD, has been investigated for its hepatoprotective effects, offering potential benefits in normalising liver enzymes and histological improvement [8]. In the realm of atrial fibrillation, treatment strategies prioritise rate and rhythm control, alongside anticoagulation to prevent thromboembolic events [9]. Therefore, it is crucial to explore potential treatment options that consider the connection between NAFLD and atrial fibrillation. However, it is important to note that these conventional approaches often treat NAFLD and atrial fibrillation in isolation, overlooking their shared pathophysiological roots.

Aim

To evaluate the efficacy of combining ursodesoxycholic acid and quercetin with standard treatment to improve liver health and heart function in patients with non-alcoholic fatty liver disease and atrial fibrillation.

Material and methods

A prospective, randomized controlled trial was conducted at the therapeutic departments of Ivano-Frankivsk Central Clinical Hospital and Ivano-Frankivsk City Clinical Hospital No. 1 from January 2020 to December 2023. The study included patients aged 18–75 years who were diagnosed with non-alcoholic fatty liver disease confirmed by ultrasound elastography and had a history of atrial fibrillation confirmed by 12-lead ECG. The diagnosis of NAFLD was established in accordance with state protocol for management of NASH [10] and atrial fibrillation in accordance with ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS) [11] and state protocol for management of atrial fibrillation [12]. The study's exclusion criteria included patients with alcohol consumption, other chronic liver diseases (such as viral hepatitis and autoimmune liver diseases), significant cardiac conditions (such as heart valve disease), and patients on anticoagulant therapy that could not be standardized.

The study included 127 patients who were divided into three groups. Group 1 (standard treatment) consisted of 42 patients, Group 2 (standard treatment + UDCA) consisted of 44 patients, and Group 3 (standard treatment + UDCA + Quercetin) consisted of 41 patients.

The study protocol was reviewed and approved by the Ethics Commission of Ivano-Frankivsk National Medical University, taking into account ethical considerations. Additionally, all participants provided written informed consent before enrollment. The study was conducted in accordance with the Declaration of Helsinki and local regulatory requirements.

Standard treatment for NAFLD consisted of dietary and lifestyle recommendations, with an emphasis on weight loss and physical activity. The management of atrial fibrillation followed current guidelines, which involved the use of rate or rhythm control medications as clinically indicated. The dosages of UDCA and quercetin were determined based on existing literature and preliminary safety assessments. UDCA was administered orally at a dose of 10 mg/kg/day, while quercetin was provided as a dietary supplement at a dose of 40 mg three times a day, both for a duration of 3 months.

The primary outcomes measured were changes in liver stiffness and fat content, as determined by ultrasound elastography and Controlled Attenuation Parameter scoring, respectively. The study also investigated changes in echocardiographic parameters, specifically ejection fraction and diastolic function, to assess cardiac function improvement. Ultrasound investigations were conducted using a Toshiba Aplio 500 ultrasound machine at a clinical base of Ivano-Frankivsk National Medical University.

Data were analyzed using IBM SPSS 26.0 (License Code QA2WSWS3QTR5TG6Y7TG6RF59JUY7H). Continuous variables were expressed as median (interquartile range), and categorical variables as numbers and percentages. Differences between groups were evaluated using Mann-Whitney test for continuous variables and

Table 1. Baseline characteristics of studied patients

Parameter, units of measurement		Group 1, n = 42	Group 2, n = 44	Group 3, n = 41	p value
Age, years		51.00 (44.25; 56.75)	52.50 (49.00; 57.00)	50.00 (46.00; 54.00)	0.214
Sex	Male	15 (35.70 %)	17 (38.60 %)	15 (36.60 %)	0.959
	Female	27 (64.30 %)	27 (61.40 %)	26 (63.40 %)	
Atrial fibrillation form	Paroxysmal	26 (61.90 %)	24 (54.50 %)	27 (65.90 %)	0.871
	Persistent	9 (21.40 %)	12 (27.30 %)	8 (19.50 %)	
	Permanent	7 (16.70 %)	8 (18.20 %)	6 (14.60 %)	
Body mass index, kg/m^2		32.61 (29.98; 36.51)	32.23 (29.75; 35.39)	33.24 (30.09; 35.79)	0.797

Table 2. Changes in intensity of fibrosis and steatosis

Parameter, units of measurement		Group 1, n = 42	Group 2, n = 44	Group 3, n = 41
Intensity of fibrosis, kPa	Pre treatment	9.83 (8.23; 10.62)	9.02 (8.24; 10.13)	7.98 (7.00; 9.98)
	Post treatment	8.73 (7.17; 9.71)	8.15 (6.95; 9.70)	7.54 (6.60; 8.36)*#
	Δ%, p	-7.03 %, p = 0.097	-9.55%, p = 0.020	-11.88 %, p = 0.018
Intensity of steatosis, dB/m	Pre treatment	278.06 (261.85; 301.44)	281.48 (265.74; 295.64)	280.97 (258.98; 292.27)
	Post treatment	280.41 (261.97; 296.81)	245,34 (222.21; 269.44)*	255,87 (219,93; 274,45)*
	Δ%, p	-0.98 %, p = 0.698	-13.33 %, p < 0.001	-9.89 %, p < 0.001

*: p value <0.05 with group 1; #: p value <0.05 between group 2 and 3.

Table 3. Changes in stage of fibrosis and steatosis

Variable name		Group 1, n = 42	Group 2, n = 44	Group 3, n = 41	p value
Stage of fibrosis pre treatment	F1	5 (11.90 %)	3 (6.80 %)	10 (24.40 %)	0.167
	F2	21 (50.00 %)	25 (56.80 %)	21 (51.20 %)	
	F3	16 (38.10 %)	16 (36.40 %)	10 (24.40 %)	
Stage of fibrosis post treatment	F1	9 (21.40 %)	13 (29.50 %)	14 (34.10 %)	0.022
	F2	23 (54.80 %)	22 (50.00 %)	27 (65.90 %)	
	F3	10 (23.80 %)	9 (20.50 %)	0 (0.00 %)	
Stage of steatosis pre treatment	S0	3 (7.10 %)	3 (6.80 %)	3 (7.30 %)	0.392
	S1	7 (16.70 %)	2 (4.50 %)	8 (19.50 %)	
	S2	16 (38.10 %)	25 (56.80 %)	17 (41.50 %)	
	S3	16 (38.10 %)	14 (31.80 %)	13 (31.70 %)	
Stage of steatosis post treatment	S0	5 (11.90 %)	20 (45.50 %)	16 (39.00 %)	0.002
	S1	4 (9.50 %)	7 (15.90 %)	8 (19.50 %)	
	S2	17 (40.50 %)	12 (27.30 %)	12 (29.30 %)	
	S3	16 (38.10 %)	5 (11.40 %)	5 (12.20 %)	

the Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

Results

In *Table 1* the baseline characteristics of studied patients are summarized.

The median age of the three groups was closely matched. Group 1 had a median age of 51 years (44.25; 56.75), Group 2 had a median age of 52.5 years (49.00; 57.00), and Group 3 had a median age of 50 years (46.00; 54.00). The age distribution between the groups was not significantly different (p = 0.214). Similarly, the sex distribution was also similar across the groups. In Group 1, 35.7 % were males and 64.3 % were females. In Group 2, 38.6 % were males and 61.4 % were females. In Group 3, 36.6 % were males and 63.4 % were females. There was no significant difference in sex composition between the groups (p = 0.959).

Paroxysmal atrial fibrillation was the most common form across all groups, observed in 61.9 % of Group 1, 54.5 % of Group 2, and 65.9 % of Group 3. Persistent atrial fibrillation was reported in 21.4 % of Group 1, 27.3 % of Group 2, and 19.5 % of Group 3. Permanent atrial fibrillation was the least common, found in 16.7 % of Group 1, 18.2 % of Group 2, and 14.6 % of Group 3. These differences were not statistically significant (p = 0.871). The Body mass index (BMI) was comparable across in all three groups, with Group 1 having a median BMI of 32.61 (29.98; 36.51) kg/m^2, Group 2 with 32.23 (29.75; 35.39) kg/m^2, and Group 3 with 33.24 (30.09; 35.79) kg/m^2. The statistical analysis revealed no significant difference in BMI among the groups (p = 0.797).

The study's randomization process successfully balanced the demographic and baseline characteristics of patients across the three treatment groups. This indicates that any differences in treatment outcomes are likely due to the interventions themselves rather than baseline disparities. The age, sex distribution, type of atrial fibrillation, and BMI were comparable across all groups.

The dynamic of liver ultrasound parameters is presented in *Tables 2* and *3*.

At the outset of the study, the median liver stiffness values measured in kilopascals (kPa) were comparable

Table 4. Changes in echocardiographic parameters

Parameter, units of measurement		Group 1, n = 42	Group 2, n = 44	Group 3, n = 41
Left atrial diameter, cm	Pre treatment	4.16 (3.77; 4.54)	4.28 (3.86; 4.43)	4.19 (3.85; 4.48)
	Post treatment	4.04 (3.69; 4.33)	4.01 (3.67; 4.34)	3.89 (3.34; 4.23)
	Δ%, p	-2.18 %, p = 0.474	-5.61 %, p = 0.055	-6.77 %, p = 0.011
Left atrial volume, mL	Pre treatment	54.58 (44.18; 65.68)	50.18 (41.08; 66.79)	50.48 (41.34; 65.49)
	Post treatment	55.67 (42.10; 65.77)	55.12 (34.66; 67.77)	49.53 (33.15; 64.26)
	Δ%, p	-0.44 %, p = 0.957	-1.80 %, p = 0.790	-6.22 %, p = 0.415
Left atrial volume index, mL/ms	Pre treatment	28.82 (24.32; 38.42)	29.63 (21.42; 37.31)	28,04 (23.62; 35.62)
	Post treatment	34.17 (25.00; 40.81)	31,57 (24.72; 37.71)	28.06 (20.55; 35.26)
	Δ%, p	6.99 %, p = 0.304	3,73 %, p = 0.595	-3.78 %, p = 0.660
Left ventricular ejection fraction, %	Pre treatment	56.00 (49.88; 59.35)	55.39 (52.35; 61.62)	56.27 (53.46; 60.81)
	Post treatment	57.75 (53.48; 60.79)	57.20 (53.09; 60.84)	60.92 (56.70; 64.67)*#
	Δ%, p	4.30 %, p = 0.073	2.55 %, p = 0.280	7.74%, p = 0.001
E/A ratio	Pre treatment	1.13 (0.85; 1.36)	1.00 (0.81; 1.27)	1.06 (0.93; 1.27)
	Post treatment	1.04 (0.91; 1.17)	1.17 (0.93; 1.49)*	1.39 (1.12; 1.66)
	Δ%, p	-12.22 %, p = 0.040	13.52 %, p = 0.069	32.04 %, p < 0.001
Isovolumic relaxation time, ms	Pre treatment	66.59 (53.78; 77.16)	66.16 (56.08; 79.07)	68.34 (58.10; 77.35)
	Post treatment	68.31 (58.91; 76.79)	79.45 (60.69; 89.16)*	70.31 (61.56; 78.19)
	Δ%, p	0.37 %, p = 0.950	14.01 %, p = 0,005	1.70 %, p = 0.760
E deceleration time, ms	Pre treatment	177.19 (145.75; 198.21)	182.30 (153.82; 204.30)	172.91 (150.40; 198.14)
	Post treatment	177.24 (140.00; 205.20)	150.59 (130.65; 178.64)*	153.43 (119.39; 182.56)*
	Δ%, p	0.49 %, p = 0.924	-12.81 %, p = 0.005	-12.99 %, p = 0.015
E/e′ ratio	Pre treatment	7.24 (6.36; 8.94)	8.68 (6.88; 9.85)	8.16 (6.22; 9.83)
	Post treatment	8.12 (6.46; 10.51)	8.30 (6.61; 10.72)	6.47 (4.64; 8.26)*#
	Δ%, p	9.59 %, p = 0.226	1.46 %, p = 0.835	-17.59 %, p = 0.034

*: p value <0.05 with group 1; #: p value <0.05 between group 2 and 3.

across all groups: 9.83 (8.23; 10.62) kPa for Group 1, 9.02 (8.24; 10.13) kPa for Group 2, and 7.98 (7.00; 9. 98) kPa for Group 3. Subsequent measurements after treatment revealed a decrease in liver stiffness in all groups, with Group 1 at 8.73 (7.17; 9.71) kPa, Group 2 at 8.15 (6.95; 9.70) kPa, and Group 3 at 7.54 (6.60; 8.36) kPa. The results show a decrease in liver stiffness of -7.03 % for Group 1 (p = 0.097), -9.55 % for Group 2 (p = 0.020), and -11.88 % for Group 3 (p = 0.018). It is worth noting that Groups 2 and 3 experienced a statistically significant reduction, with Group 3 showing the most significant improvement. Before treatment, the distribution of fibrosis stages was relatively balanced across the groups, with similar percentages of patients in stages F1, F2, and F3. Following treatment, a significant shift in fibrosis stages was observed. It is noteworthy that Group 3 exhibited a marked reduction in advanced fibrosis, with no patients remaining in the F3 stage after treatment (p = 0.022).

Baseline levels of steatosis, measured in decibels per meter (dB/m), were similar across all groups. After the intervention, significant reductions in steatosis levels were observed in Groups 2 and 3. Specifically, Group 2 experienced a decrease from 281.48 dB/m to 245.34 dB/m, representing a -13.33 % reduction (p < 0.001). Similarly, Group 3 experienced a decrease from 280.97 dB/m to 255.87 dB/m, representing a -9.89 % reduction (p < 0.001). In contrast, Group 1 showed a non-significant change (-0.98 %, p = 0.698). The study found a significant increase in the proportion of patients classified as S0 (no steatosis) after treatment in Groups 2 and 3 (p = 0.002), with 45.5 % and 39.0 % of patients in the S0 stage, respectively, compared to 11.9 % in Group 1.

Changes in echocardiographic parameters are summarized in *Table 4*.

Initially, the left atrial diameter measurements were similar across all three groups. After treatment, a reduction in left atrial diameter was observed in all groups. Group 3 exhibited the most significant decrease (-6.77 %, p = 0.011), suggesting a potential improvement in atrial remodeling. In contrast, the changes in Groups 1 and 2 were less pronounced and did not reach statistical significance. Although Group 3 showed a slight decrease (-6.22 %, p = 0.415), it was not statistically significant. There were no significant changes observed in left atrial volume across the groups after treatment. Similarly, the left atrial volume index did not show significant improvements across the groups.

However, the left ventricular ejection fraction, an important measure of cardiac function, improved in all groups, with the most significant increase observed in Group 3 (7.74 %, p = 0.001). The results indicate that the combined treatment regimen in Group 3 may have resulted in improved cardiac efficiency. These findings demonstrate the potential benefits of the combined treatment regimen in Group 3.

Specifically, Group 3 showed a significant increase in the E/A ratio (32.04 %, p < 0.001), which suggests improved diastolic filling and potentially better overall cardiac function. In contrast, Group 1 experienced a decrease in the E/A ratio, while Group 2 showed a non-significant increase. Isovolumic relaxation time, which reflects the time taken for the ventricles to relax, increased significantly only in Group 2 (14.01 %, p = 0.005). The E deceleration time, which measures the rate of decline in early diastolic filling velocity, showed a significant decrease in Groups 2 and 3, suggesting an improvement in early diastolic filling and potentially reduced left atrial pressure. The E/e' ratio, which is commonly used to estimate left ventricular

filling pressure, showed a significant decrease in Group 3 (-17.59 %, p = 0.034). This suggests a possible reduction in left ventricular diastolic pressure and an improvement in cardiac function. However, no significant changes were observed in Groups 1 and 2.

Discussion

The analysis indicates that the addition of UDCA and quercetin to standard treatment regimens can significantly reduce liver stiffness and improve steatosis levels. The group treated with both UDCA and quercetin showed the most significant changes. These findings are consistent with recent research that highlights the hepatoprotective effects of UDCA and the anti-inflammatory and antioxidant properties of quercetin [13,14]. For instance, the study conducted by [15] demonstrated that UDCA has the ability to modulate bile acid composition and reduce liver inflammation. Additionally, P. Cao et al. found that quercetin can attenuate oxidative stress and improve liver histology in a NAFLD model [16].

The combined treatment also exhibited promising effects on cardiac parameters, such as left atrial diameter, left ventricular ejection fraction, and diastolic function indicators. The improvement in left ventricular ejection fraction in the combined treatment group suggests enhanced cardiac efficiency, which may be attributed to the systemic benefits of quercetin. This is consistent with L. Wang et al.'s findings, which reported improved cardiac output and reduced myocardial fibrosis with quercetin supplementation in a heart failure model [17].

The observed improvement in the E/A ratio and reduction in E/e' ratio may indicate better diastolic function and lower left ventricular filling pressures. This finding is consistent with K. Moonikh et al., who also noted similar improvements in diastolic function with antioxidant therapy in patients with metabolic syndrome and subclinical heart disease [18]. These results suggest that antioxidant therapy may be a promising approach for improving diastolic function in patients with metabolic syndrome and subclinical heart disease.

In comparison to the existing literature, our study takes a unique approach by addressing both NAFLD and atrial fibrillation through a combined pharmacological approach. While previous studies have separately investigated the effects of UDCA and quercetin on liver and heart health [19,20], our research highlights the potential synergistic effects of these agents when used together.

Our study's findings suggest that integrating UDCA and quercetin with Standard treatments may provide a more comprehensive approach to managing patients with NAFLD and atrial fibrillation, addressing both hepatic and cardiac aspects of these conditions. Future research will focus on long-term outcomes, potential side effects, and optimal dosing and administration strategies for these treatments.

Conclusions

1. The addition of ursodesoxycholic acid and quercetin to standard treatment regimens significantly improved liver health, as evidenced by reductions in liver fibrosis and steatosis, in patients with non-alcoholic fatty liver disease and atrial fibrillation.

2. Significant enhancements in cardiac function were observed, particularly in left ventricular ejection fraction and diastolic function parameters, indicating potential cardioprotective effects of the combined pharmacological approach.

3. The findings suggest a synergistic effect of ursodesoxycholic acid and quercetin when used alongside standard treatments, highlighting the benefits of a comprehensive treatment strategy that addresses both hepatic and cardiac aspects of non-alcoholic fatty liver disease and atrial fibrillation.

4. These results underscore the potential of integrating ursodesoxycholic acid and quercetin into treatment protocols for patients with non-alcoholic fatty liver disease and atrial fibrillation, offering a novel approach to managing these interrelated conditions more effectively.

Prospects for further research. Future plans include closer examination of left atrial and left ventricular changes in patients with non-alcoholic fatty liver disease and atrial fibrillation and to develop new treatment strategies to alleviate the inflammatory damage.

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