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CLINICAL RESEARCH

Prevalence of Liver Steatosis and Fibrosis and the Diagnostic Accuracy of Ultrasound in Bariatric Surgery Patients

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Abstract
Background Liver steatosis can progress to fibrosis, cirrhosis, and eventually to end-stage liver disease and hepatocellular carcinoma. We thus determined the prevalence of liver steatosis and fibrosis in patients undergoing bariatric surgery using liver biopsy. We also determined the suitability of ultrasound for diagnosis of liver steatosis with and without simultaneously considering patient characteristics.
Methods We reviewed preoperative liver ultrasound and intraoperative liver biopsy results in 451 bariatric surgery patients along with their clinical characteristics between 2005 and 2009.
Results Among 435 patients with conclusive biopsy results, estimated prevalence of liver steatosis was 71.5% (95% confidence interval 67%, 76%) and that of fibrosis was 27% (23%, 31%). Sensitivity of ultrasound for liver steatosis was 86% (82%, 90%); its specificity was 68% (59%, 76%). Positive predictive value of ultrasound for liver steatosis was 87% (82%, 91%), and its negative predictive value was 67% (58%, 75%). Overall diagnostic accuracy was 81% (77% 85%). Sensitivity was improved in patients with higher nonalcoholic fatty liver disease activity scores (NAS) [odds ratio (OR) 1.4 (1.1, 1.9) for a one unit increase in NAS] and prolonged duration of obesity [OR 1.3 (1.1, 1.6) for a 5-year increase in duration] but was worsen by higher body mass index.
Conclusions About three quarters of bariatric surgery patients have liver steatosis, and about a quarter have fibrosis. One third of patients with liver steatosis develop fibrosis without significant clinical manifestations. Ultrasound was only moderately diagnostic for liver steatosis but was sufficient for clinical use in patients with a NAS score ≥2 and when the duration of obesity was >30 years.

Keywords Morbid obesity · Liver steatosis · Liver fibrosis · Ultrasound

Background

Morbid obesity is often defined as a body mass index (BMI) exceeding 35 kg/m^2 combined with at least one

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obesity-associated disease, or a BMI exceeding 40 kg/m^2 with or without obesity-associated diseases. The prevalence of morbid obesity is rising in the USA, and approximately 14 million people are already affected [1–3].

Morbid obesity is often accompanied by liver steatosis. Liver steatosis, defined as fat accumulation exceeding 5% of normal liver wet weight, is a chronic disorder which encompasses both alcoholic and nonalcoholic etiologies. The progressive form of the disease, steatohepatitis, can progress to fibrosis, cirrhosis, and eventually to end-stage liver disease and hepatocellular carcinoma. All these patients have potential for perioperative coagulopathy and metabolic derangements.

Based on results of magnetic resonance spectroscopy or liver histopathology, the prevalence of liver steatosis may be as high as 34% in the US general population [4, 5]. Estimates for the prevalence of liver steatosis in morbidly obese subjects ranges from 70% to 96% [6–8]. However, the prevalence of this liver steatosis in the morbidly obese remains unclear. Our first goal was thus to determine the prevalence of steatosis and fibrosis in morbidly obese subjects, as determined by liver biopsies—which are considered the "gold standard" diagnostic tool for this condition.

It is well established that ultrasound can detect uniform fatty infiltration of liver, although distinguishing between hepatic steatosis and progressive steatohepatitis remains challenging [9]. Ultrasound is an attractive screening tool, especially in the morbidly obese population with its high prevalence of liver steatosis, because it is inexpensive, safe, and well tolerated by patients. The reported sensitivity for ultrasound detection of liver steatosis varies from 60% to 94% while the reported specificity of varies from 84% to 95% [10–13]. However, none of these studies was primarily conducted in a large morbidly obese population. The distinction is important because the quality of ultrasonic images is presumably degraded in morbidly obese patients due to thickening of the abdominal wall which could easily reduce diagnostic accuracy. Our second goal was thus to determine the accuracy of ultrasonic diagnosis of liver steatosis in morbidly obese patients, considering clinical characteristics might also influence the diagnostic value of ultrasound for steatosis and help the clinician interpret ultrasound results.

Methods

With approval of the Cleveland Clinic Institutional Review Board, we evaluated a cohort of patients who had laparoscopic gastric bypass, sleeve, or band surgery. We included patients who had no clinical evidence of other liver diseases and who had intraoperative needle liver biopsy with or without preoperative right upper quadrant ultrasound between 2005 and 2009.

Right upper quadrant ultrasound is offered to all bariatric surgery patients at the Cleveland Clinic as part of their routine preoperative assessment for laparoscopic procedures. All of the exams were performed by certified sonography technicians with multiple grayscale images of the right upper quadrant, including a representative sagittal sonographic plane showing hepatic parenchyma and the adjacent right kidney. Ninety-six percent of exams were performed within the 2 months before surgery. An Acuson Antares Premium Edition (Siemens, Munich, Germany) with a 3.0–5.0-MHz curved array transducer was routinely used.

The echogenicity of the right renal cortex or spleen, beam attenuation with standard settings, visualization of the echogenicity of the walls surrounding intrahepatic vessels, and degree of reflectivity from the diaphragm were interpreted by a limited number of designated staff abdominal radiologists with at least 10 years of experience who were routinely involved in ultrasound diagnosis of liver steatosis. Normal, fat-free liver can be recognized based on similar echogenicity of the liver, renal cortex, and the spleen and by well-defined diaphragmatic and portal veins (Fig. 1a). Liver steatosis was recognized by "bright liver" caused by increased echogenicity compared with the renal cortex and was suggested by loss of detail of the portal veins (Fig. 1b). Other diagnoses (i.e., tumor) were indicated by hyperechogenic, hypoechogenic, necrotic masses, or diffuse alteration of echo architecture.

For analysis purposes, ultrasound interpretations were classified into four categories based on radiologists' descriptions and interpretations: (1) normal; (2) suspected liver steatosis, alone, or coexisting with other disease; (3) inconclusive; or (4) other suspected liver diseases. Classification was performed by an investigator who was unaware of the patient's clinical condition (other than being a bariatric surgery patient) and the biopsy findings. Inter-interpreter bias was possibly involved, but classification was generally simple and straightforward. Less than 7% of uncertain scans with characteristic echogenicity features but without final diagnosis of fatty liver required consultation and confirmation from Cleveland Clinic staff radiologists. Severity of liver steatosis was not routinely graded based on ultrasound; consequently, grade was not included in our analysis and steatosis was considered a dichotomous outcome. Ultrasounds were inconclusive in about 1% of cases when the quality was inadequate for evaluation because of the patient's habitus, internal gas, or scarring.

Intraoperative liver needle biopsy is performed routinely in our bariatric surgical patients. Biopsies were performed by bariatric surgeons under direct visualization with a modified Menghini technique 7 using a 14-gauge 15-cm

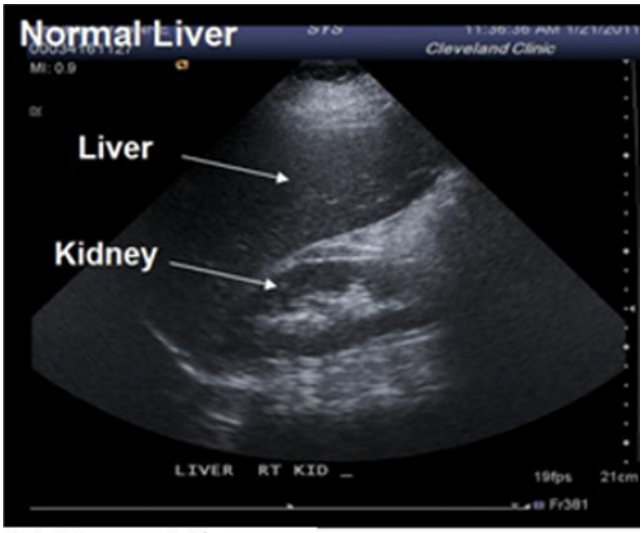

Fig. 1 **a** Ultrasound scan of normal liver. Note the similar echogenicity of liver and renal cortex; **b** ultrasound scan of a fatty liver showing increased echogenicity ("bright" liver), compared with the renal cortex

Tru-cut (Allegiance Healthcare Corp., McGaw Park, IL, USA) biopsy needle. When pathology was grossly apparent, the most suspicious area was selected for biopsy. A single hepatopathologist blinded to ultrasound findings evaluated the liver biopsy specimens to establish normal liver (Fig. 2a) or the pathologic diagnosis. Steatosis involving 5% or more of the parenchyma was considered pathologic (Fig. 2b). A diagnosis of steatohepatitis was established based on an overall pattern of injury characterized by steatosis (greater than or equal to 5%), inflammation, and ballooning hepatocyte degeneration (Fig. 2c). In patients with a histologic diagnosis of steatosis or steatohepatitis, the nonalcoholic fatty liver disease activity score (NAS) was determined as the unweighted sum of scores for steatosis, lobular inflammation, and ballooning hepatocyte degeneration. This score ranges from 0 to 8 over the full spectrum of lesion of fatty liver disease. Fibrosis in the biopsy specimen was staged from 0 to 4, as previously reported (Fig. 2d) [14].

For analysis purposes, histological descriptions were classified into four categories: (1) normal histology, (2) liver steatosis alone or coexisting with other diagnoses, (3) inconclusive, or (4) other liver pathology including autoimmune hepatitis, virus hepatitis, Wilson's disease, hemachromatosis, or α1-antitrypsin deficiency. Inconclusive pathology occurred when collected liver specimens were inadequate for evaluation (biopsies that were entirely subcapsular or contained fewer than six portal tracts), which was the case in about 2% of samples. Classification of histological descriptions was performed by an investigator who was unaware of the patient's clinical condition (other than being a bariatric surgery patient) and the ultrasound findings. The duration of obesity was determined by a questionnaire routinely completed by bariatric surgery patients.

We recorded clinical characteristics including diabetes, plasma triglycerides, cholesterol, very-low-density lipoprotein, low-density lipoprotein, aspartate aminotransferase, alanine aminotransferase, NAS score, BMI, and duration of obesity. We also evaluated metabolic syndrome, clinically defined by the presence of any three of the following five traits: (1) abdominal obesity, defined as a waist circumference in men >102 cm (40 in.) and in women >88 cm (35 in.); (2) serum triglycerides ≥150 mg/dL (1.7 mmol/L) or drug treatment for elevated triglycerides; (3) serum high-density lipoprotein (HDL) cholesterol <40 mg/dL (1 mmol/L) in men and <50 mg/dL (1.3 mmol/L) in women or drug treatment for low HDL-C; (4) blood pressure ≥130/85 mmHg or drug treatment for elevated blood pressure; and (5) fasting plasma glucose ≥110 mg/dL or drug treatment for elevated blood glucose [15].

Data Analysis

Primary Analysis The prevalence of liver steatosis and fibrosis in our bariatric surgery population was estimated as the proportion of patients who had liver biopsy results diagnostic for steatosis or steatohepatitis and the proportion of patients who had fibrosis grades 1 to 4, respectively. The corresponding 95% confidence intervals (CI) were estimated using the exact binomial method.

Secondary Analysis Diagnostic accuracy of ultrasound for detection of liver steatosis was evaluated with patients who had conclusive results from both liver biopsy and ultrasonography. Overall sensitivity, specificity, positive predictive value (PPV), negative predictive

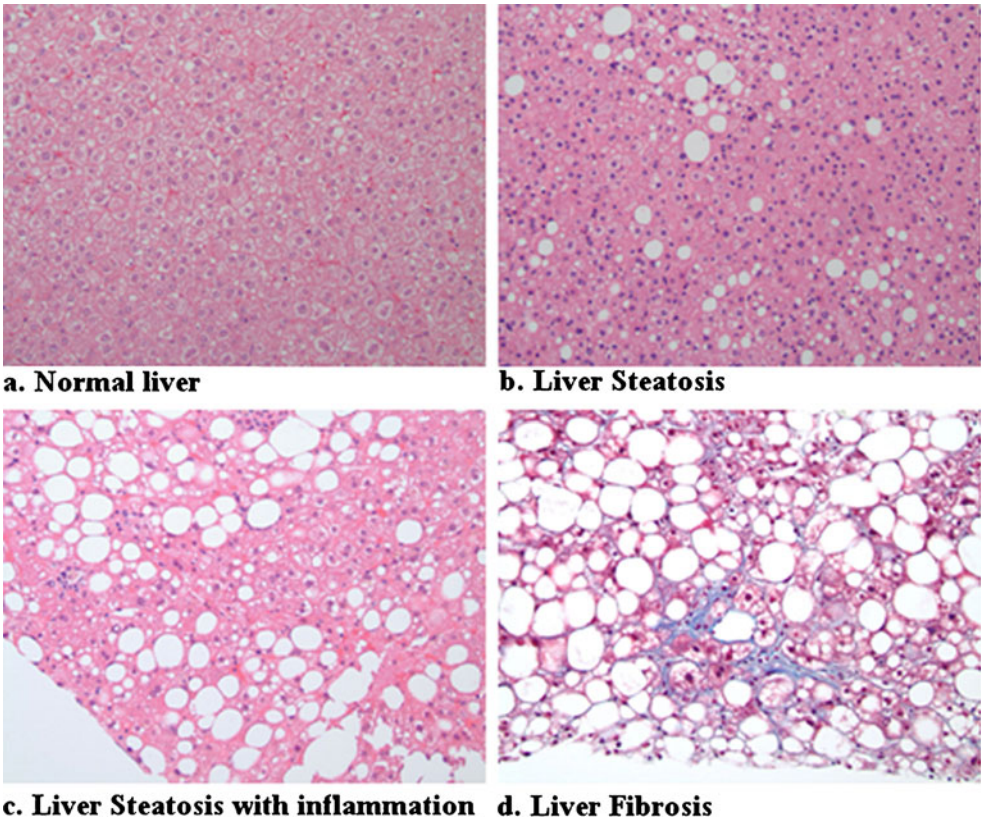

Fig. 2 **a** Normal liver H&E original magnification, ×200; **b** liver steatosis H&E original magnification, 200×; **c** liver steatosis with inflammation H&E original magnification, 200×; **d** liver fibrosis Masson's trichrome original magnification, 200×

value (NPV), and accuracy were estimated, along with their 95% exact confidence intervals.

Sensitivity of a test is defined by the probability of testing positive for a disease, assuming the disease is present; this probability can be modeled using logistic regression on the subset of patients with disease (positive biopsy). Using the subset of patients with positive liver biopsy, we evaluated relationships between sensitivity (i.e., the probability of a positive ultrasound in these patients) and BMI, duration of obesity, as well as severity of fatty liver disease (NAS score), using a single multivariable logistic regression. We also adjusted for *pre-specified* potential confounders—diabetes and metabolic syndrome. We allowed for possible nonlinearities in the relationships by visually examining smooth terms, using thin-plate regression splines and a smoothing parameter estimated from cross-validation. Similarly, the relationships between the BMI and duration of obesity and specificity (in patients with negative biopsies) and accuracy (in all patients) were evaluated, by multivariable logistic models adjusting for diabetes and metabolic syndrome as well. NAS scores was only included when assessing the association with sensitivity because by definition patients with negative liver biopsy had NAS score of 0.

In addition, we estimated univariable diagnostic accuracy (i.e., sensitivity, specificity, PPV, NPV, and accuracy) of ultrasound scans for the detection of liver steatosis within each BMI range (i.e., ≤40, 40–50, and >50 kg/m^2) and duration of obesity range (i.e., ≤20, 20–30, and >30 years). The sensitivity of ultrasound was also estimated univariably within categories of NAS score (i.e., 0–1, 2–4, and 5–7). The confidence intervals were estimated using the exact binomial method.

SAS software version 9.2.2 for Windows (SAS Institute, Cary, NC, USA) and R software version 2.12.0 for Windows (The R Foundation for Statistical Computing, Vienna, Austria) were used for all statistical analyses. No correction was made for multiple testing in the secondary analyses.

Results

A total of 451 patients had bariatric surgery at the Cleveland Clinic between 2005 and 2009, of whom only eight (2%) did not have biopsies done at the discretion of the surgeon (because patients were Jehovah's witnesses, were coagulopathic, or refused). Four hundred forty-three (98%) had intraoperative liver biopsies, of which eight liver biopsies were inconclusive because of technically unsatisfactory samples, leaving 435 patients with conclusive biopsy results. Demographics of these patients, along with their clinical characteristics (including body mass index,

duration of obesity, diabetes status, metabolic syndrome, hypertension, hyperlipidemia, plasma triglycerides concentration, cholesterol level, high- and low-density lipoprotein concentrations, transaminase concentrations, fibrosis, and NAS scores), are summarized in Table 1. Twenty-two patients did not have ultrasound scans, and scans were inconclusive in three others due to intestinal gas, obesity, or internal scarring. Diagnostic biopsy and ultrasound results were thus both available in 410 patients. The duration of obesity or NAS score was missing from the medical records of 21 patients, leaving 389 patients for evaluation of how these factors influence diagnostic accuracy of ultrasound (Fig. 3).

Among the 435 patients with conclusive biopsy results, 124 (28.5%) did not have liver steatosis (including 119 patients with normal liver and five patients with other histologic diagnoses), and 311 (71.5%) had either liver steatosis only or coexisting liver steatosis. Based on these patients, the prevalence of liver steatosis was estimated at 71.5% (95% CI 67%, 76%). Assuming the inconclusive results were truly free of liver steatosis, the prevalence was estimated to be 70.2% (311 of 443, 95% CI 66%, 74%). Alternately, assuming those patients truly had liver steatosis, this prevalence estimate was 72.0% (319 of 443, 95% CI 68%, 76%). Thus, our point estimates of the prevalence of liver steatosis ranged between 70.2% and 72.0%. On the whole, we estimated the prevalence of liver steatosis to be anywhere between 66% and 76% among bariatric surgery patients receiving an intraoperative liver biopsy test at our institution between 2005 and 2009. We also observed 116 patients with fibrosis; the prevalence was estimated at 27% (116 of 435, 95% CI 23%, 31%).

Among the 410 patients with conclusive diagnostic biopsy and ultrasound results, each combination of ultrasound and liver biopsy test results is provided in Table 2. Ultrasound detected 86% (95% CI 82%, 90%) of the liver steatosis cases (sensitivity) and was positive for 32% (24%, 41%) of non-liver steatosis patients. The specificity was thus 68% (59%, 76%). The positive predictive value of ultrasound for liver steatosis was 87% (82%, 91%), and its negative predictive value was 67% (58%, 75%). Overall diagnostic accuracy was 81% (77%, 85%; Table 3).

The relationships between the measures of diagnostic accuracy of ultrasound for liver steatosis and BMI, duration of obesity, and NAS score were evaluated in 389 patients in whom all data were available. There was no compelling evidence of nonlinear associations. A linear relationship was thus assumed between each variable and each diagnostic accuracy measures of interest (specifically, the logit of the outcome proportion) in our logistic regression models.

After adjusting for BMI, duration of obesity, diabetes status, and metabolic syndrome, we found that higher NAS score (i.e., more severe liver steatosis) was associated with

Table 1 Summary of baseline variables (N=435)

Variables	Statistics
Age, years	46±12
Gender (male), %	27
Height, cm	168±9
Weight, kg	128 (114, 148)
Body mass index, kg/mg^2	45 (41, 52)
Duration of obesity[a], year	22±11
Diabetes (yes), %	60
Metabolic syndrome (yes), %	67
Hypertension (yes), %	64
Hyperlipidemia (yes), %	63
Plasma TG[b], %	128 (97, 184)
Cholesterol[b], mg/dL	181 (157, 207)
HDL[b], mg/dL	48±12
LDL[c], mg/dL	106±33
VLDL[d], mg/dL	26 (19, 35)
AST[e], U/L	22 (18, 29)
ALT[e], U/L	22 (16, 33)
Elevated AST (≥40 U/L)[e], %	12
Elevated ALT (≥45 U/L)[e], %	11
Elevated AST or ALT[e], %	15
Fibrosis, %	
0	73
1	15
2	6
3	5
4	<1
NAS score[f], %	
0	27
1	25
2	19
3	11
4	8
5	7
6	4
7	<1

Four hundred thirty-five patients with conclusive biopsy results. Mean±SD, median (Q1, Q3), or percent, as appropriate

ALT alanine aminotransferase, *AST* aspartate aminotransferase, *HDL* high-density lipoprotein cholesterol, *LDL* low-density lipoprotein cholesterol, *VLDL* very-low-density lipoprotein

[a] Seven patients

[b] Thirty patients

[c] Forty patients

[d] Forty-seven patients

[e] Four patients with missing values, respectively

[f] Seventeen patients were not listed: among them six patients were diagnosed as inconclusive; eleven patients were diagnosed with other etiologies

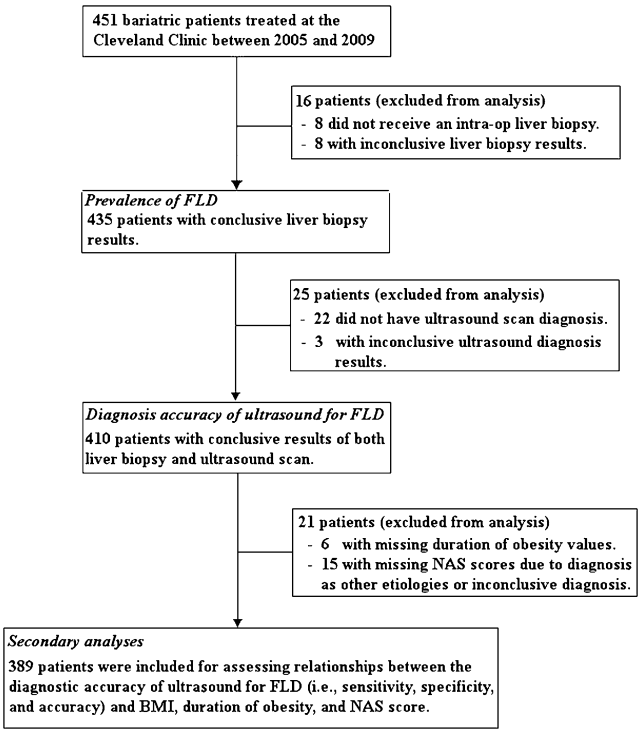

Fig. 3 Study flow diagram

increased odds of being diagnosed with liver steatosis by ultrasound among patients who actually had liver steatosis (sensitivity) [OR (95% CI) 1.4 (1.1, 1.9) for a one unit increase in NAS score, P=0.01]. Higher body mass index was associated with lower sensitivity [OR (95% CI) 0.81, (0.66, 0.99), for a 5-kg/m^2 increase in BMI, P=0.04], and prolonged duration of obesity was associated with higher sensitivity [OR (95% CI) 1.3 (1.1, 1.6) for a 5-year increase in duration, P=0.01]. However, no other significant associations were found (Table 4).

In addition, the univariable ultrasound diagnostic accuracy results within each BMI and duration of obesity category were consistent with our multivariable results (Table 5); for example, sensitivity increase as duration of obesity increases from ≤20 to >30, but no such trend was observed for specificity, PPV, or NPV. The sensitivity of ultrasound increases as NAS score increases [estimated sensitivities (95% CI)—0.77 (0.67, 0.85), 0.90 (0.83, 0.94), and 0.95 (0.85, 0.99) for NAS score of 0–1, 2–4, and 5–7, respectively], which is consistent with our multivariable results.

Table 2 Summary of fatty liver disease diagnosis based on ultrasound scan and liver biopsy (gold standard) (N=410)

		Liver biopsy test results		
		Positive	Negative	Total
Ultrasound results	Positive	251 (61%)	38 (9%)	289 (70%)
	Negative	40 (10%)	81 (20%)	121 (30%)
	Total	291 (71%)	119 (29%)	N=410

Results presented as number (percent) for cell counts. Four hundred ten patients with conclusive results of both diagnostic biopsy and ultrasound

Table 3 Comparison of ultrasound scan (diagnostic test) and liver biopsy test (gold standard) results for the detection of fatty liver disease (N=410)

	Estimate (95% CI)
Sensitivity	0.86 (0.82, 0.90)
Specificity	0.68 (0.59, 0.76)
Positive predictive value	0.87 (0.82, 0.91)
Negative predictive value	0.67 (0.58, 0.75)
Accuracy (TP+TN)/total N	0.81 (0.77, 0.85)

Four hundred ten patients with conclusive results of both diagnostic biopsy and ultrasound. TP=true positive; TN=true negative

Discussion

Histology represents the gold standard for a diagnosis of liver steatosis. Both the prevalence of liver steatosis and the diagnostic accuracy of ultrasound depend on the amount of steatosis that is considered pathologic. We, as others [14], considered steatosis of 5% or more to be pathologic. Using this definition, we found that nearly three quarters (71.5%) of our bariatric surgery patients had some degree of liver steatosis (95% CI 67%, 76%). Our results are thus at the

Table 4 Multivariable associations between diagnostic accuracy of ultrasound scan for detection of fatty liver disease and BMI, duration of obesity, and the severity of fatty liver disease (NAS scoring) in 389 patients

Outcome	Factor	OR unit	Odds ratio (95% CI)	P
Sensitivity	NAS score	1	1.44 (1.10, 1.88)	0.01
	BMI	5	0.81 (0.66, 0.99)	0.04
	Duration of obesity	5	1.34 (1.09, 1.63)	0.01
Specificity	BMI	5	1.07 (0.84, 1.36)	0.61
	Duration of obesity	5	0.92 (0.76, 1.12)	0.42
Accuracy	BMI	5	0.96 (0.83, 1.10)	0.54
	Duration of obesity	5	1.11 (0.97, 1.26)	0.12

From a multivariable model including NAS score, BMI in kg/m2, duration of obesity in years, and the pre-specified confounders (i.e., diabetes status and metabolic syndrome). NAS score was only included when assessing the association with sensitivity because by definition patients with negative liver biopsy had NAS score of 0. Three hundred eighty-nine patients with conclusive results of both diagnostic biopsy and ultrasound and non-missing values of the above three factors

Table 5 Univariable diagnostic accuracy of ultrasound scan for detection of fatty liver disease within each level of NAS Score and each range of BMI and duration of obesity (total N=389)

Factor	Sensitivity (95% CI)[a]	Specificity (95% CI)[a]	PPV (95% CI)[a]	NPV (95% CI)[a]	Accuracy (95% CI)[a]
Body mass index, kg/m^2					
≤40	0.89 (0.78, 0.96)	0.65 (0.41, 0.85)	0.88 (0.76, 0.95)	0.68 (0.43, 0.87)	0.83 (0.72, 0.9)
(40, 50]	0.88 (0.81, 0.93)	0.66 (0.52, 0.78)	0.87 (0.81, 0.92)	0.67 (0.53, 0.8)	0.82 (0.76, 0.87)
>50	0.82 (0.72, 0.89)	0.69 (0.49, 0.85)	0.89 (0.81, 0.95)	0.54 (0.37, 0.71)	0.79 (0.7, 0.85)
Duration of obesity, years					
≤20	0.81 (0.74, 0.87)	0.74 (0.6, 0.84)	0.89 (0.83, 0.94)	0.59 (0.47, 0.71)	0.79 (0.73, 0.84)
(20, 30]	0.87 (0.77, 0.94)	0.59 (0.39, 0.76)	0.84 (0.73, 0.91)	0.65 (0.44, 0.83)	0.79 (0.69, 0.86)
>30	0.97 (0.89, 1)	0.56 (0.3, 0.8)	0.9 (0.8, 0.96)	0.82 (0.48, 0.98)	0.89 (0.8, 0.95)
All 389 patients	0.86 (0.82, 0.90)	0.67 (0.57, 0.76)	0.88 (0.84, 0.91)	0.63 (0.53, 0.72)	0.81 (0.77, 0.85)

NPV negative predictive value, *PPV* positive predictive value

[a] Confidence intervals were estimated by the exact binomial method

lower end of previous estimates that ranged from 70% to 96% [6–8].

The ≈70% prevalence of liver steatosis among bariatric surgery patients is nonetheless substantial, and clinicians should consider the syndrome in obese subjects. Ultrasound is an attractive diagnostic option since it avoids the risk, discomfort, and cost associated with liver biopsies. And in theory, ultrasound might diagnose liver steatosis relatively objectively by comparing the fat-induced increase in echogenicity of hepatic tissue with the renal cortex. Consistent with this theory, various investigators report that ultrasonography has a sensitivity of 80–94% and a specificity of 84–93% for detecting histological steatosis in mostly non-obese subjects [11–13]. Our results, however, indicate that ultrasound is only moderately effective for diagnosis of liver steatosis in morbidly obese subjects: Sensitivity was 86%, specificity 68%, and overall accuracy was 81%. A moderately good correlation between ultrasound and histopathologic liver steatosis was also observed in two small population studies with unknown BMI or only slight obesity [16, 17].

Diagnostic accuracy would surely be improved by considering a greater percentage of fat to be pathologic, with a consequence of missing less severe cases. For example, previous studies report that hepatic steatosis >30% reliably produce the diagnostic brightly reflective echo pattern [5, 18, 19]. Our results are consistent with this theory: More fat gives a higher NAS score, which significantly improved sensitivity by about 40% per NAS point. The duration of obesity also significantly increased sensitivity—presumably by increasing severity and thus facilitating diagnosis. In contrast, higher body mass index was associated with lower sensitivity [OR (95% CI) 0.81 (0.66, 0.99), for a five-unit increase in BMI, P=0.04], presumably because the thick abdominal wall degrades the ultrasound signal.

It is likely that the prevalence of liver steatosis would be similar in comparably obese patients not having bariatric surgery. However, it could be less to the extent that suspected or known liver steatosis—or related complications—is an indication for surgery (selection bias). But even an unlikely factor-of-2 reduction in the prevalence among non-surgical subjects would leave the prevalence at about a third of all morbidly obese subjects—which is still remarkably high. Clinicians should thus assume morbidly obese subjects are at high risk for liver steatosis and thus the associated potential for perioperative coagulopathy and metabolic derangements.

The ≈27% prevalence of liver fibrosis among our bariatric surgery patients seems surprisingly high, especially given the lack of clinical symptoms and signs of liver disease except in 15% of patients who had slightly increased levels of liver transaminases. It is clinically important, but also technically challenging, to evaluate hepatic fibrosis non-invasively. Theoretically, fibrosis might be distinguished from fat by a coarser echo pattern and by increased definition of portal veins along with other ancillary signs of portal hypertension, with typical cirrhotic tissue reflecting attenuated and irregular echoes. However, fat alone can account for increased attenuation in patients with cirrhosis [20], with normal echogenicity being observed in macronodular but not micronodular cirrhosis [21]. The echo pattern alone was thus inadequate for making a specific ultrasonic diagnosis of focal/heterogeneous fibrosis and cirrhosis [22]. We were therefore unable to discuss the diagnostic accuracy of ultrasound on the occurrence of fibrosis in our patients who were obese and having bariatric surgery and who did not have clinical symptoms and signs of liver disease.

In summary, the prevalence of biopsy-confirmed liver steatosis was 67–76% and that of fibrosis was 23–31% in bariatric surgery patients. One third of patients with fatty

liver develop fibrosis, typically without clinical manifestations. Clinicians should thus assume morbidly obese subjects are at high risk for liver steatosis and fibrosis and thus the associated potential for perioperative coagulopathy and metabolic derangements. Ultrasound was only moderately diagnostic, with a sensitivity of 86%, specificity of 68%, and overall diagnostic accuracy of 81%. Ultrasonography alone—with current techniques—thus does not appear sufficiently accurate to replace biopsies. But when considering other clinical characteristics, its diagnostic value was certainly high enough for clinical use in patients with NAS score ≥2 and/or obesity lasting >30 years.

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