Table S1 Baseline characteristics of patients with or without partial missing data of body composition

Characteristics	Without missing BIA (n=690)	Partial missing BIA data (n=76)	P value
Demographics			
Age (years)	41.6±12.5	36.1±11.4	<0.001
Male sex, n (%)	499 (72.3)	49 (64.5)	0.150
BMI (kg/m^2)	26.9±3.8	29.4±4.1	<0.001
Type 2 diabetes, n (%)	178 (25.8)	12 (15.8)	0.055
Hypertension, n (%)	162 (23.5)	12 (15.8)	0.129
Biochemical measurements			
Albumin (g/L)	46.0±3.9	46.8±3.6	0.091
Platelet count (×10^9)	244.5±62.5	238.0±58.3	0.387
AST (U/L)	34.0 (25.0, 52.0)	37.0 (25.0, 56.2)	0.485
ALT (U/L)	49.5 (30.0, 87.8)	67.1 (34.8, 104.0)	0.016
ALP (U/L)	82.0 (67.2, 99.8)	80.0 (69.0, 94.6)	0.526
Glucose (mmol/L)	5.3 (4.9, 6.3)	5.3 (4.8, 5.9)	0.112
Total cholesterol (mmol/L)	5.1 (4.4, 5.9)	5.1 (4.3, 6.0)	0.383
Triglycerides (mmol/L)	1.9 (1.4, 2.9)	1.7 (1.2, 2.5)	0.058
HDL-C (mmol/L)	1.0±0.3	1.1±0.2	0.002
LDL-C (mmol/L)	3.0±0.9	3.3±0.9	0.004
CK-18 M30 (U/L)	156.1 (74.8, 345.2)	–	–
Body composition			
Body composition analysis			
Intracellular water (e)	24.6±4.7	24.5±4.4 [74]	0.769
Extracellular water (e)	14.8±2.6	16.0±2.4 [74]	<0.001
Total body water (e)	39.5±7.3	40.4±6.7 [74]	0.301
Soft lean mass (g)	50.6±9.7	52.9±9.6 [74]	0.051
Fat free mass (kg)	53.8±10.1	56.6±10.2 [74]	0.022
Muscle-fat analysis			
Weight (kg)	75.9±14.0	82.6±14.7	<0.001
Skeletal muscle mass (kg)	30.1±6.0	32.1±9.9 [47]	0.038
Body fat mass (kg)	22.1±7.4	25.9±9.2	<0.001
Obesity diagnosis			
Percent body fat (%)	28.8±6.6	31.0±7.8	0.008
Waist-hip ratio	0.9±0.0	0.9±0.1 [47]	<0.001

Table S1 (*continued*)

Table S1 (*continued*)

Characteristics	Without missing BIA (n=690)	Partial missing BIA data (n=76)	P value
Lean balance			
Right arm (kg)	3.1±0.7	3.1±1.0	0.882
Left arm (kg)	3.0±0.7	3.0±1.0	0.966
Trunk (kg)	24.6±4.3	25.0±5.7	0.366
Right leg (kg)	8.1±1.7	9.3±2.7	<0.001
Left leg (kg)	8.1±1.7	9.3±2.7	<0.001
Visceral fat area			
Visceral fat area (cm^2)	102.2±27.5	101.0±34.5 [42]	0.701
Additional data			
Body cell mass (kg)	35.3±6.6	38.6±6.9 [11]	0.097
Bone mineral content (kg)	3.0±0.6	3.1±0.6 [40]	0.082
Basal metabolic rate (kcal)	1,537.0±240.7	1,555.1±259.0	0.538
Arm circumference (cm)	33.4±3.1	34.9±1.6 [9]	0.152
Arm muscle circumference (cm)	27.3±2.5	28.2±2.2 [9]	0.259
Non-invasive NASH scores			
ION	38.5 (23.1, 66.6) [625]	29.4 (14.1, 40.6) [26]	0.043
HAIR	1.0 (1.0, 2.0) [670]	1.0 (1.0, 2.0) [61]	0.922
NICE	−2.6 (−3.9, −0.8) [532]	−	−
Liver histology, n (%)			
Steatosis			0.020
1	280 (40.6)	20 (26.3)	
2	272 (39.4)	42 (55.3)	
3	138 (20.0)	14 (18.4)	
Hepatocyte ballooning			0.013
0	85 (12.3)	1 (1.3)	
1	369 (53.5)	43 (56.6)	
2	236 (34.2)	32 (42.1)	
Lobular inflammation			0.004
0	67 (9.7)	2 (2.6)	
1	388 (56.2)	59 (77.6)	
2	222 (32.2)	14 (18.4)	
3	13 (1.9)	1 (1.3)	

Table S1 (*continued*)

Table S1 (*continued*)

Characteristics	Without missing BIA (n=690)	Partial missing BIA data (n=76)	P value
Fibrosis stage			0.126
0	213 (30.9)	16 (21.1)	
1	325 (47.1)	36 (47.4)	
2	123 (17.8)	21 (27.6)	
3/4	29 (4.2)	3 (3.9)	
NAS	4.0 (3.0, 5.0)	4.5 (4.0, 5.0)	0.089
NASH, n (%)	452 (65.5)	64 (84.2)	<0.001

[n]: the numbers of data available. BIA, bioelectrical impedance analysis; BMI, body mass index; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; CK-18 M30, cytokeratine-18 neoepitope M30; NASH, non-alcoholic steatohepatitis; NAS, NAFLD activity score.

Table S2 Baseline characteristics of patients, stratified by NASH or non-NASH on histology in the training or validation groups

Characteristics	Training group (n=613)			Validation group (n=153)		
	Non-NASH (n=195)	NASH (n=418)	P value	Non-NASH (n=55)	NASH (n=98)	P value
Demographics						
Age (years)	43.9±11.6	40.2±12.9	<0.001	43.1±9.8	38.2±12.9	0.017
Male sex, n (%)	149 (76.4)	291 (69.6)	0.082	44 (80.0)	64 (65.3)	0.056
BMI (kg/m^2)	26.0 (24.1, 27.7)	27.3 (24.8, 29.7)	<0.001	25.3 (23.4, 27.7)	27.1 (25.0, 29.8)	0.003
Type 2 diabetes, n (%)	47 (24.1)	100 (23.9)	0.961	17 (30.9)	26 (26.5)	0.563
Hypertension, n (%)	48 (24.6)	89 (21.3)	0.358	13 (23.6)	24 (24.5)	0.906
Biochemical measurements						
Albumin (g/L)	45.7±3.6	46.3±4.0	0.031	44.9±4.0	46.8±3.8	0.002
Platelet count (×10^9)	240.9±61.0	244.4±62.5	0.467	251.6±66.6	243.3±60.8	0.588
AST (U/L)	27.0 (22.0, 35.5)	39.0 (27.0, 58.0)	<0.001	26.0 (20.5, 34.0)	47.0 (30.0, 64.8)	<0.001
ALT (U/L)	38.0 (25.0, 57.5)	61.0 (38.0, 104.0)	<0.001	34.0 (21.0, 56.5)	68.5 (36.6, 130.8)	<0.001
ALP (U/L)	80.0 (66.0, 98.5)	83.0 (69.3, 99.0)	0.118	74.0 (60.5, 88.0)	83.0 (68.2, 103.5)	0.019
Glucose (mmol/L)	5.2 (4.8, 6.0)	5.4 (4.9, 6.4)	0.017	5.4 (4.9, 6.8)	5.3 (4.9, 6.5)	0.905
Total cholesterol (mmol/L)	4.9 (4.0, 5.5)	5.2 (4.4, 6.0)	<0.001	4.9 (4.3, 5.5)	5.4 (4.6, 6.0)	0.024
Triglycerides (mmol/L)	1.8 (1.2, 2.5)	2.0 (1.5, 3.0)	<0.001	1.9 (1.4, 3.0)	1.7 (1.3, 2.5)	0.302
HDL-C (mmol/L)	1.0±0.3	1.0±0.3	0.106	1.0 (0.2)	1.1 (0.2)	0.015
LDL-C (mmol/L)	2.9±0.8	3.1±0.9	0.002	3.0 (0.9)	3.2 (1.0)	0.259
CK-18 M30 (U/L)	105.3 (55.0, 175.0)	214.8 (108.5, 468.5)	<0.001	107.6 (54.8, 155.9)	345.0 (148.8, 678.1)	<0.001
Body composition						
Body composition analysis						
Intracellular water (e)	24.6±4.1	24.6±5.0	0.865	24.8±4.1	24.4±4.6	0.524
Extracellular water (e)	14.9±2.4	15.0±2.8	0.684	15.0±2.3	14.7±2.6	0.348
Total body water (e)	39.6±6.7	39.7±7.6	0.799	39.8±6.4	39.0±7.1	0.440
Soft lean mass (g)	50.9±8.8	50.9±10.3	0.835	51.0±8.6	50.2±9.2	0.529
Fat free mass (kg)	53.9±8.9	54.3±11.0	0.654	54.3±8.8	53.2±9.8	0.454
Muscle-fat analysis						
Weight (kg)	74.4±12.6	78.1±15.1	0.002	72.7±10.6	77.0±13.8	0.102
Skeletal muscle mass (kg)	30.2±5.4	30.5±6.9	0.715	30.3±5.5	29.7±6.0	0.531
Body fat mass (kg)	20.4±6.8	23.6±7.9	<0.001	18.3±5.1	23.7±7.5	<0.001
Obesity diagnosis						
Percent body fat (%)	27.2±6.5	30.1±6.6	<0.001	25.2±5.8	30.6±6.9	<0.001
Waist-hip ratio	0.9±0.0	0.9±0.1	0.084	0.9±0.0	0.9±0.1	0.012

Table S2 (*continued*)

Table S2 (*continued*)

Characteristics	Training group (n=613)			Validation group (n=153)		
	Non-NASH (n=195)	NASH (n=418)	P value	Non-NASH (n=55)	NASH (n=98)	P value
Lean balance						
Right arm (kg)	3.1±0.6	3.1±0.8	0.541	3.1±0.7	3.0±0.7	0.286
Left arm (kg)	3.1±0.6	3.0±0.8	0.884	3.1±0.7	3.0±0.7	0.338
Trunk (kg)	24.7±3.8	24.6±4.7	0.965	24.8±4.3	24.2±4.3	0.306
Right leg (kg)	8.3±1.6	8.3±2.0	0.607	8.2±1.6	8.1±1.6	0.985
Left leg (kg)	8.2±1.6	8.3±2.0	0.658	8.1±1.6	8.1±1.6	0.955
Visceral fat area						
Visceral fat area (cm^2)	97.4±24.4	104.7±29.2	0.008	92.3±23.6	106.4±28.9	0.002
Additional data						
Body cell mass (kg)	35.2±5.8	35.5±7.0	0.666	35.5±6.0	35.0±6.7	0.631
Bone mineral content (kg)	2.9±0.5	3.0±0.6	0.250	2.9±0.5	3.0±0.6	0.896
Basal metabolic rate (kcal)	1,535.9±204.0	1,544.2±268.0	0.630	1,551.9±217.7	1,514.1±210.9	0.326
Arm circumference (cm)	32.9±2.5	33.8±3.4	0.002	32.7±2.6	33.6±3.2	0.110
Arm muscle circumference (cm)	27.2±2.2	27.4±2.6	0.229	27.5±2.6	27.1±2.7	0.343
Non-invasive NASH scores						
LEARN	0.50±0.03	0.53±0.02	<0.001	0.50±0.03	0.53±0.03	<0.001
ION	29.0 (15.4, 45.8)	43.9 (27.8, 71.1)	<0.001	25.1 (15.5, 37.1)	44.6 (33.5, 83.1)	<0.001
HAIR	1.0 (0.0, 1.0)	1.0 (1.0, 2.0)	<0.001	1.0 (0.0, 1.0)	1.0 (1.0, 2.0)	<0.001
NICE	−3.4 (−4.5, −2.1)	−2.0 (−3.2, 0.3)	<0.001	−3.6 (−4.5, −2.4)	−0.9 (−3.2, 2.6)	<0.001
Liver histology, n (%)						
Fibrosis stage			<0.001			<0.001
0	111 (56.9)	73 (17.5)		31 (56.4)	14 (14.3)	
1	67 (34.4)	223 (53.3)		21 (38.2)	50 (51.0)	
2	11 (5.6)	101 (24.2)		1 (1.8)	31 (31.6)	
3/4	6 (3.1)	21 (5.0)		2 (3.6)	3 (3.1)	

NASH, non-alcoholic steatohepatitis; BMI, body mass index; AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; CK-18 M30, cytokeratine-18 neoepitope M30; LEARN, bioeLectrical impEdance Analysis foR Nash.

Table S3 Diagnostic performance of LEARN algorithm in groups of patients with or without partial missing data of body composition

Grouping	n	AUROC	95% CI
With or without partial missing BIA data			
WMBC group	690	0.80	(0.77, 0.83)
PMBC group	76	0.82	(0.72, 0.92)

LEARN, bioeLectrical impEdance Analysis foR Nash; AUROC, area under the receiver operating characteristics; CI, confidence interval; BIA, bioelectrical impedance analysis; WMBC, without partial missing data of body composition; PMBC, partial missing data of body composition.
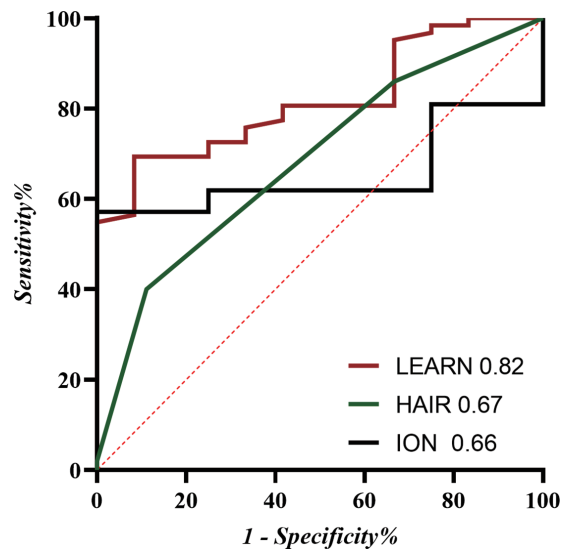

Figure S1 Pairwise comparison of ROC curves between the deep neural network model for identifying NASH (LEARN algorithm) and ION and HAIR models in the group of patients with partial missing data of body composition.