# Multiparametric Ultrasound Diagnostics with Artificial Intelligence Programs in Diffuse Liver Diseases in Children

RETROSPECTIVE DIAGNOSTIC-ACCURACY STUDY · PEDIATRIC COHORT (N = 185) · STARD 2015 / TRIPOD+AI COMPLIANT

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## BACKGROUND

- Liver biopsy is the reference standard for chronic diffuse liver disease but is **limited in pediatrics** by invasiveness, complication risk, and ethics.
- 2D shear-wave elastography (SWE) and Doppler enable non-invasive monitoring, yet interpretation remains **operator-dependent**.
- B-mode sensitivity for early fibrosis (F0–F2) is limited; radiomic texture analysis with machine learning may add objectivity.
- Evidence for AI-augmented ultrasound in **pediatric** cohorts is sparse — children have different acoustic tissue properties than adults.

## AIM

To evaluate and compare the diagnostic performance of **multiparametric ultrasound (B-mode + 2D-SWE + hepatic-vein Doppler)** combined with two machine-learning algorithms for non-invasive staging of liver fibrosis in children with diffuse liver disease.

## COHORT

| 185 | 582 | 10.8±3.3 |
|---|---|---|
| CHILDREN | ROIS | AGE (YR) |

| | |
|---|---|
| **Main group (CDLD)** | n = 140 · 60.7% girls |
| **Controls** | n = 45 · 71.2% girls |
| **MASLD** | 46.4% |
| **Wilson's disease** | 17.9% |
| **Autoimmune hepatitis** | 16.4% |
| **Chronic hepatitis B / C** | 11.4% / 7.9% |

## METHODS · MULTIPARAMETRIC US + AI PIPELINE

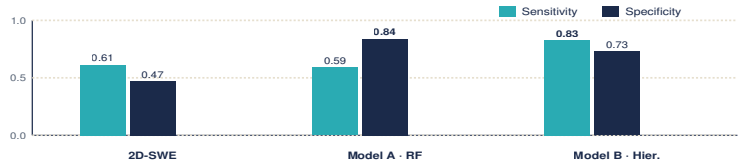
**B-mode**
**5–10 images**
**Aplio 500 / 800**
→
**ROI extraction**
**2 expert readers**
**(consensus)**
→
**Radiomic**
**texture**
**features**

**Model A**
**Random Forest**
**binary (norm / path.)**
↓ vs ↓
**Model B**
**Hierarchical ensemble**
**multiclass F0–F4**
↔
**2D-SWE**
**reference**
**(WFUMB 2024)**

**Model A features:** first-order statistics (mean, variance, skewness) + Haralick texture descriptors from the gray-level co-occurrence matrix. **Model B:** cascaded binary classifiers — F0 vs F≥1, then F1 vs F≥2, etc. **Validation:** patient-level 80 / 10 / 10 split (train / val / held-out test). **Doppler:** hepatic-vein waveform with standard + high-frequency (5.3–17 MHz) linear probe. Reporting: STARD 2015 + TRIPOD+AI.

## RESULTS · DIAGNOSTIC PERFORMANCE (NORM VS PATHOLOGY, F ≥ 1)

| Index test | Sensitivity | Specificity | Accuracy |
|---|---|---|---|
| **Elastography (2D-SWE)** | 0.61 | 0.47 | 0.59 |
| **Model A · Random Forest (binary)** | 0.59 | **0.84** | 0.67 |
| **Model B · Hierarchical (F ≥ 1)** | **0.83** | **0.73** | **0.83** |




## KEY FINDINGS

- **ρ = 0.77** — strong Spearman correlation between Model B and 2D-SWE fibrosis staging.
- **Model A** — highest specificity (**0.84**): a conservative rule-in tool.
- **Model B** — highest sensitivity (**0.83**): detects subtle early texture changes, at the cost of over-calling moderate fibrosis.
- Monophasic hepatic-vein Doppler waveform correlates with higher fibrosis (**ρ up to 0.93**).
- High-frequency linear probe detected microcirculatory changes in MASLD that standard convex imaging missed.

## DOPPLER · WAVEFORM CORRELATION WITH FIBROSIS

| Waveform (HF probe) | ρ · SWE | ρ · Model A | ρ · Model B |
|---|---|---|---|
| **Monophasic** | 0.75 | **0.93** | **0.93** |
| **Biphasic** | 0.31 | 0.77 | 0.71 |
| **Triphasic** | –0.77 | –0.71 | –0.89 |

Spearman ρ computed at nosology-group level (n = 6). Loss of triphasic pattern reflects sinusoidal remodelling and elevated intrahepatic vascular resistance.

## CONCLUSIONS

1. Multiparametric ultrasound with AI image analysis yields an **objective, reproducible** framework for non-invasive pediatric fibrosis stratification.
2. Models A and B show **complementary profiles** — high-specificity rule-in vs. high-sensitivity screening.
3. Best SWE agreement at the **extremes (F0 and F3–F4)**; F1 ↔ F2 remains the principal calibration target.
4. Doppler waveform analysis (esp. HF probe) adds **independent hemodynamic evidence** of progression.
5. Prospective multicenter validation and threshold calibration are required before clinical deployment.

**REFERENCES**

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*Research tool — not a replacement for clinical diagnosis.*