

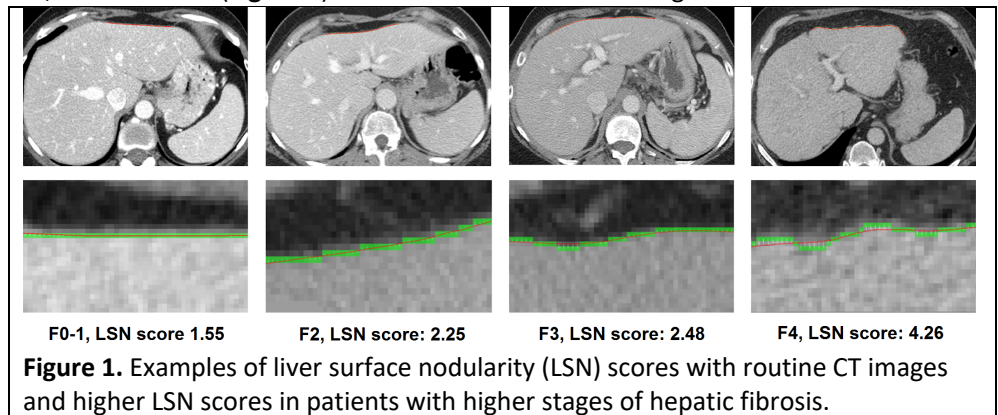
## CT Liver Surface Nodularity

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**Introduction:** Liver fibrosis leads to development of fibrotic bands and regenerative nodules that contribute to increased liver surface nodularity (LSN) as the degree of liver fibrosis worsens. Using imaging software, LSN can be quantified on routine abdominal CT images to obtain a LSN score, or Liver Score (**Figure 1**).<sup>1-10</sup> The LSN score is the average distance between the detected liver surface and a smoothed polynomial line.

Ten contiguous slices are evaluated for a total distance of 80 to 100 cm, and the final LSN score is the average LSN score from each slice, expressed in tenths of a millimeter. The average image processing time is <2 minutes. The LSN score typically ranges from 1.5 to 5.0, but advanced cirrhosis with severe liver surface nodularity can have a higher LSN score.



**Staging Hepatic Fibrosis:** In studies comparing the LSN score to the stage of HCV hepatic fibrosis on biopsy, the range of accuracy (AUC) for differentiating early fibrosis ( $\geq$ F2), advanced fibrosis ( $\geq$ F3) and cirrhosis (F4) were: 0.88-0.90, 0.89-0.93, and 0.90-0.96, respectively.<sup>1-4</sup> The accuracy for staging hepatic fibrosis was further improved when mathematically combined with the fibrosis 4 (FIB-4) index, which includes patient age, basic serum liver function tests, and platelet count.<sup>5</sup>

**Substaging Cirrhosis:** The LSN score has also been used to substage cirrhosis and was highly predictive of hepatic decompensation and death in a large cohort (N=830) with a variety of forms of cirrhosis.<sup>6</sup>

**Predicting Clinically Significant Portal Hypertension:** The LSN score had high diagnostic accuracy (AUC: 0.87) for detecting clinically significant portal hypertension, outperforming liver and splenic volumes and serum indices.<sup>7-8</sup>

**Precision Analysis:** The LSN score had very high correlation ( $r = 0.810-0.960$ ) between nonenhanced and contrast-enhanced CT images in the same patients with multiphasic liver CT exams.<sup>2,9</sup> The LSN score also had high repeatability across the normal range of CT image acquisition parameters (ICC: 0.79-0.99), very high reproducibility across 22 different CT scanners from 4 different manufacturers (ICC: 0.94; CV: 9%), and very high test-retest reliability (ICC: 0.82; CV: 12%).<sup>9</sup> The software-based LSN score had higher inter-observer agreement among a group of 12 readers than subjective visual scoring (ICC: 0.84 vs. 0.61).<sup>9</sup> The technical failure rate in most studies was 0%, though one study reported 3.9%.<sup>1-10</sup>

**Advantages:** The advantages of the LSN score are high accuracy and precision (for staging hepatic fibrosis, substaging cirrhosis, predicting clinically significant portal hypertension, and future liver-related events), vendor neutral method, rapid image acquisition and processing, no need for patient fasting, no need for additional hardware, very low technical failure rate, and applicability to existing routine CT images, including noncontrast CT images.

**Disadvantages:** The disadvantages of the CT LSN score are the need for ionizing radiation, limited validation for staging liver fibrosis across all forms of CLD, and relative contraindications including ascites, very low body mass index with no perihepatic fat (potentially leading to technical failures), and pregnancy with the associated radiation risks to the fetus. Of note, a limited abdominal CT could be used to obtain the LSN score and reduce the effective radiation dose and cost.

### References:

1. Lubner MG and Pickhardt PJ. Multidetector computed tomography for retrospective, noninvasive staging of liver fibrosis. *Gastroenterol Clin North Am* 2018; 47:569-584.
2. Smith AD, Branch CR, Zand K, et al. Liver surface nodularity quantification from routine CT images as a biomarker for detection and evaluation of cirrhosis. *Radiology* 2016; 280:771-781.
3. Pickhardt PJ, Malecki K, Kloke J, Lubner MG. Accuracy of liver surface nodularity quantification on MDCT as a noninvasive biomarker for staging hepatic fibrosis. *Amer J Roentgenol* 2016; 207:1-6.
4. Lubner MG, Jones D, Adnan S, et al. Accuracy of liver surface nodularity quantification on MDCT for staging hepatic fibrosis in patients with hepatitis C virus. *Abdom Radiol* 2018; 43:2980-2986.
5. Pickhardt PJ, Graffy PM, Said A, et al. Multi-parametric CT for noninvasive staging of hepatitis C virus-related liver fibrosis: Correlation with the histopathologic fibrosis score. *Amer J Roentgenol* 2018; 212:1-7.
6. Smith AD, Zand KA, Florez E, et al. Liver surface nodularity score allows prediction of cirrhosis decompensation and death. *Radiology* 2017; 283:711-722.
7. Sartoris R, Rautou PE, Elkrief L, et al. Quantification of liver surface nodularity at CT: Utility for detection of portal hypertension. *Radiology* 2018; 289:698-707.
8. Smith AD. Enter the era of quantitative liver CT. *Radiology* 2018; 298:708-709.
9. Smith A, Varney E, Zand K, et al. Precision analysis of a quantitative CT liver surface nodularity score. *Abdom Radiol* 2018; 43:3307-3316.
10. Smith AD, Abou Elkassem A, Lirette S, et al. Accuracy of the liver surface nodularity score on CT for staging HCV hepatic fibrosis: A multi-institutional study. *Radiological Society of North America Annual Meeting; Chicago, IL. November 2018.*