

Appendix

Illustration of the iso-depth line

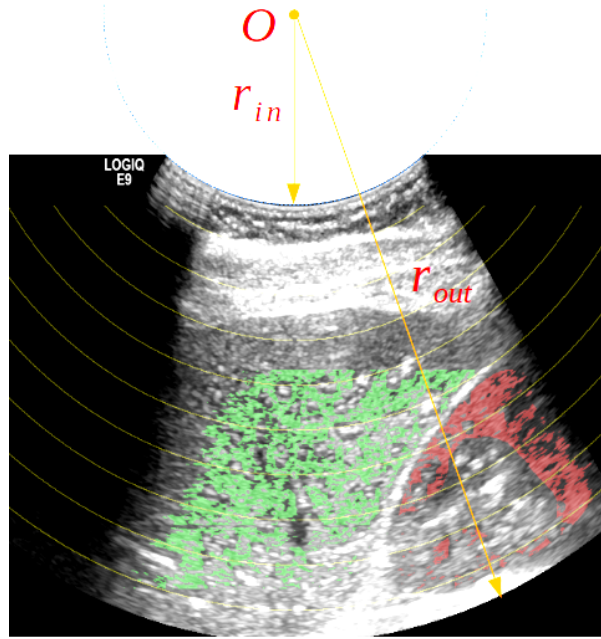


Figure A1. Illustration of the iso-depth line definition. O indicates the geometrical origin of the transducer. The iso-depth line is defined as arcs of any circle centered at O, shown by the dashed yellow curves.

Computation of HRI in Equations

The following equation defines the calculation of HRI as the ratio of mean intensity values inside the liver and the renal cortex ROIs.

$$HRI = \frac{L_l^c(x_l, y_l)}{L_k^c(x_k, y_k)} \quad (1)$$

subject to:

$$\min_{\forall x_l, y_l, x_k, y_k} w_1 \cdot ED((x_l, y_l), (x_k, y_k)) + w_2 \cdot ID((x_l, y_l), (x_k, y_k)) + w_3 \cdot MD((x_l, y_l), (x_k, y_k)) + w_4 \cdot TD((x_l, y_l), (x_k, y_k)) \quad (2)$$

subject to:

$$N_l^c(x_l, y_l) \geq T_l \quad (3)$$

$$N_k^c(x_k, y_k) \geq T_k \quad (4)$$

(x_l, y_l) : centroid of valid pixels within the liver ROI;

(x_k, y_k) : centroid of valid pixels within the renal cortex ROI;

$L_l^c(x, y)$: average intensity of the liver ROI centered at (x, y) ;

$L_k^c(x, y)$: average intensity of the renal cortex ROI centered at (x, y) ;

$N_l^c(x, y)$: number of valid pixels within the liver ROI centered at (x, y) ;

$N_k^c(x, y)$: number of valid pixels within the renal cortex ROI centered at (x, y) ;

$ED((x_1, y_1), (x_2, y_2))$: Euclidean distance between (x_1, y_1) and (x_2, y_2) ;

$ID((x_1, y_1), (x_2, y_2))$: difference between iso-depth lines through (x_1, y_1) and (x_2, y_2) ;

$CD((x_1, y_1), (x_2, y_2))$: maximum of the distances from (x_1, y_1) or (x_2, y_2) to the centerline of image;

$DP((x_1, y_1), (x_2, y_2))$: maximum of the depths of (x_1, y_1) and (x_2, y_2) ;

w_i : weights of measures;

T_l : threshold of valid pixel number for liver ROIs;

T_k : threshold of valid pixel number for renal cortex ROIs.

Representative Cases for ROI Placement

Three representative cases with varying steatosis levels (S0, S1, and S2) are presented to demonstrate the ability and the limitations of the automated HRI calculation methods.

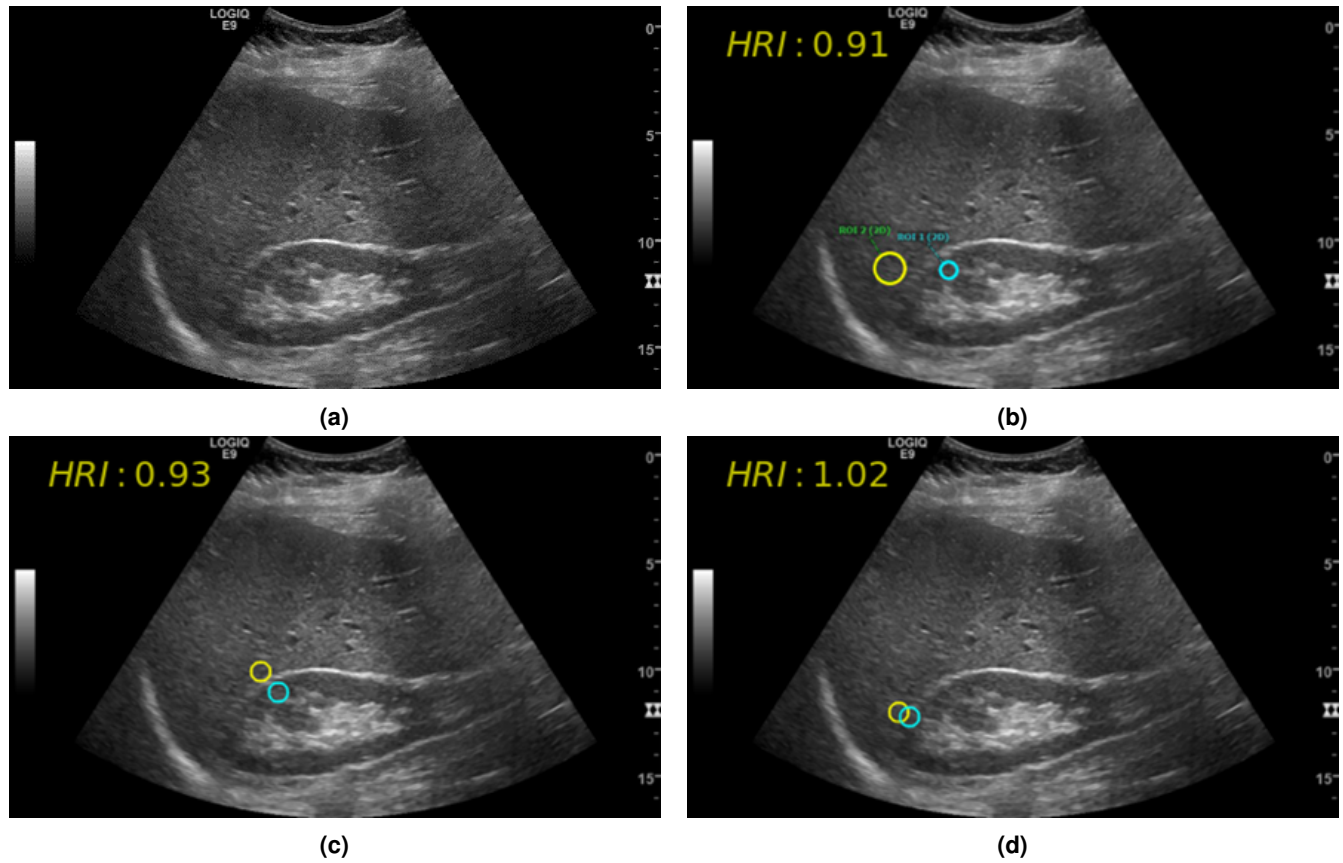


Figure A2. ROI placement for a case with biopsy-confirmed steatosis grade zero. (a) B-mode image of biopsy-proven steatosis grade zero. Images showing circular ROI placement by (b) Physician, (c) Clinical-guideline constraint, and (d) Euclidean-distance constraint. HRI values are presented on the image. In (b), a larger ROI is picked in the liver as it is easier to find a larger homogenous region in the liver. The Euclidean-distance constraint doesn't constraint the ROIs to be entirely within the liver or renal cortex; the ROIs might be partially outside the liver or renal cortex. All the methods correctly predict the steatosis grade based on the calculated HRI values, based on the reported HRI cut-off value to detect steatosis^{2,2,2}.

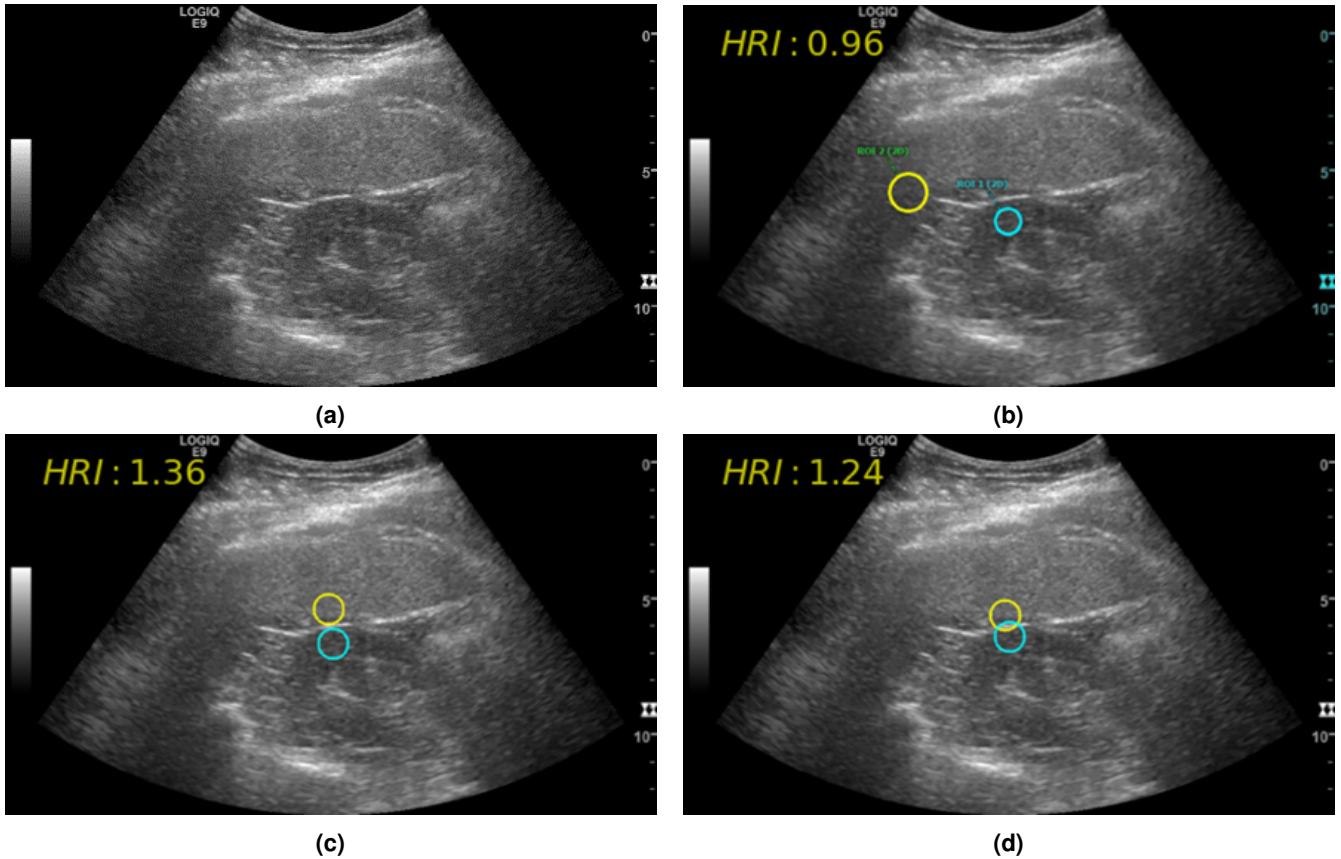


Figure A3. ROI placement for a case with biopsy-confirmed steatosis grade one. (a) B-mode image of biopsy-proven steatosis grade one. Images showing circular ROI placement by (b) Physician, (c) Clinical-guideline constraint, and (d) Euclidean-distance constraint. HRI values are presented on the image. The physician placed the liver ROI close to the shadowing artifacts in (b) to ensure the two ROIs are at a similar depth. Only a tiny portion of the liver is at the same depth as the renal cortex. The calculated HRI value is 0.91, too low for steatosis grade one. The automated methods by the clinical-guideline and the Euclidean-distance constraints placed ROIs at different depths ((c) and (d)) while avoiding shadowing artifacts, and their predicted HRI values are consistent with the pathological steatosis of grade one.

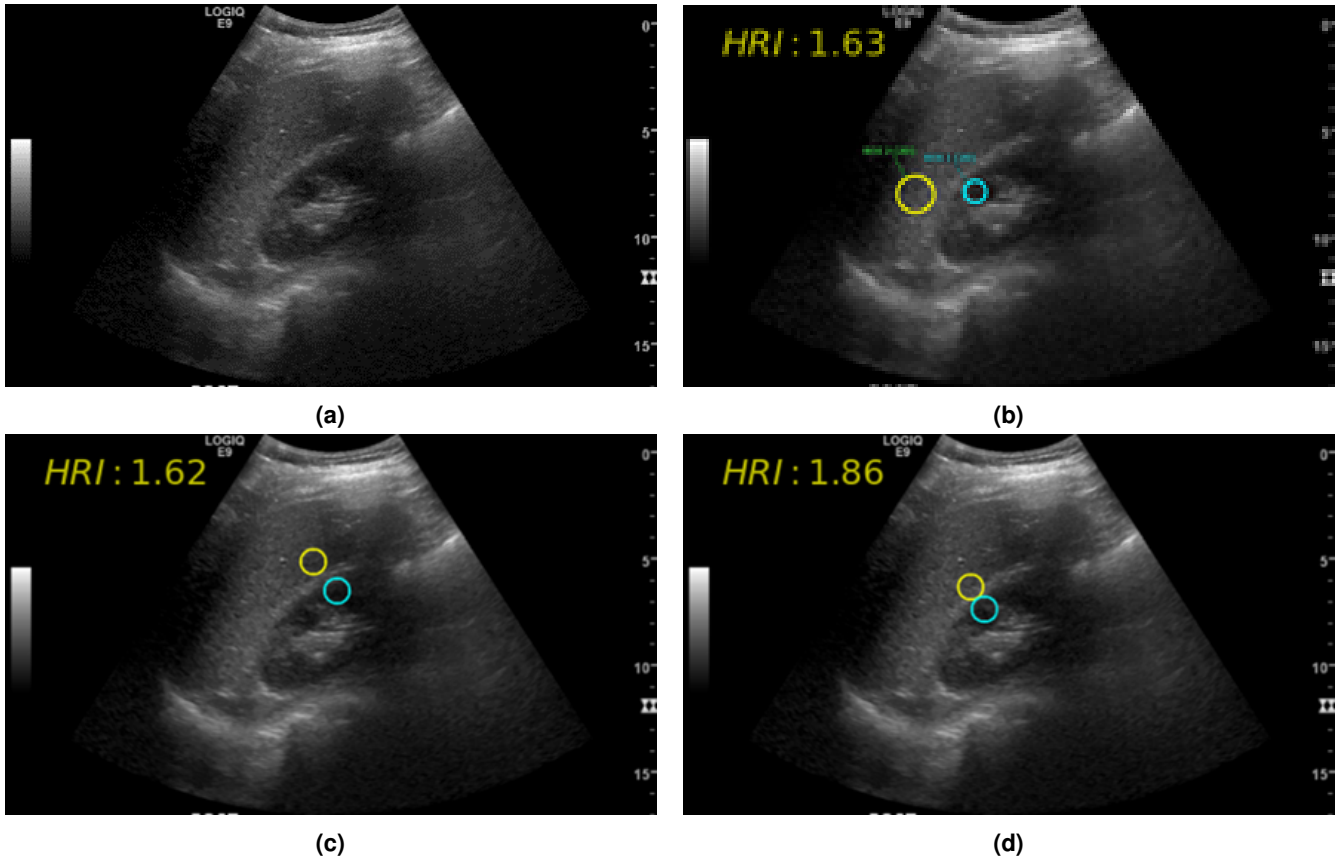


Figure A4. ROI placement for a case with biopsy-confirmed steatosis grade two. (a) B-mode image of biopsy-proven steatosis grade two. Images showing circular ROI placement by (b) Physician, (c) Clinical-guideline constraint, and (d) Euclidean-distance constraint. HRI values are presented on the image. There is a large area of acoustic shadowing close to the center of the image, thus limiting the view of the liver and the renal cortex areas. The physician placed the liver ROI a little far from the centerline of the image as shown in (b). The automated methods by the clinical-guideline and the Euclidean-distance constraints ((c) and (d)) placed ROIs at slightly different depths but close to each other. All the calculated HRI values for case 3 are higher than for cases 1 and 2, and consistent with histopathology findings.