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Utility of the Virtual Liver Parenchymal Perfusion Area Using a Commercially Available Workstation and Liver Analysis Software in Conventional Transatrerial Chemoembolization for Hepatocellular Carcinoma

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Conflict of Interest

- We have no conflicts of interest to declare.

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Background ①

- Transarterial chemoembolization (TACE) is an effective therapeutic option for unresectable hepatocellular carcinoma (HCC) [1, 2].
- The success of TACE is determined by the identification of the tumor-feeding vessel and complete embolization of the entire tumor, including the safety margin [3, 4].
- Development of automated tumor-feeder detection (AFD) software for angiography now facilitates easy detection of tumor-feeding vessels on 3-dimensional (3-D) workstations [4-7]. However, AFD software does not show the optimal catheter position, and it is often difficult to determine the territory covered by the tumor-feeder, including the normal area.

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Background ②

- Virtual parenchymal perfusion (VPP) software shows the arterial territory [3, 4] in TACE, but this is prototype software that is not yet commercially available.

- Therefore, we used a commercially available 3-D workstation and liver analysis software to estimate the liver parenchymal perfusion area [5].

- This is a specific application of this workstation for operative simulations using the dominant region extraction function of the portal vein and other veins [6-9].

Purpose

- The purpose of this retrospective study was to evaluate the accuracy of the virtual liver parenchymal perfusion area using this workstation and software in conventional TACE (cTACE) for HCC.

Materials and Methods

Patient selection

- Between July 2016 and June 2017, 144 TACE procedures were performed at Tokushima Red Cross Hospital.

- The inclusion criteria for this study were as follows.

1. cTACE performed in the sub-segmental hepatic arteries or more distally (superselective or ultraselective cTACE) and not via extrahepatic collateral vessels.
2. Newly developed HCC.
3. Follow-up by non-contrast-enhanced computed tomography (CT) that showed a clearly embolic area of each HCC.

Materials and Methods

Patient characteristics

Number of patients	23
Number of tumors	29
Age (years) *	73.8±8.41 (52, 87)
Sex (male/female)	15/8
Etiology (HCV/HBV/alcohol/others)	12/6/2/3
Child-Pugh class (A/B)	18/5
Tumor location (S1/3/4/5/6/7/8)	2/4/2/3/6/6/6
Tumor size (mm) *	16.8±9.1 (6.6, 40.7)

HCV: hepatitis C virus, HBV: hepatitis B virus
*Mean ± SD (minimum, maximum)

Materials and Methods

Estimation and evaluation of real embolic area

- The real embolic area (REA) was defined as that in which iodized oil accumulated on follow-up CT images that was performed 1 week after cTACE.

- The volume and maximum cross-sectional areas of iodized oil accumulation in the tumor in the axial, coronal, and sagittal planes for the REA were measured by two observer groups using the workstation.

  ※ Each group comprised an interventional radiologist and a radiological technician, with 10 years (group A; experts: M.K. and Y.N.) or 5 years (group B; semi-experts: K.T. and S.I.).

- The mean REA between groups A and B (mREA) was used for reference.

Materials and Methods

Estimation and evaluation of virtual embolic area

- Group A and B used a commercial 3-D workstation and liver analysis software (Synapse Vincent ver. 5.2; Fujifilm, Tokyo, Japan) to estimate VEA.

- The cone beam CT (CBCT) (XperCT; Philips Healthcare, Best, The Netherlands) images were randomized, and there was a 4 week interval between estimation and evaluation of VEA and final estimation and evaluation of REA to reduce bias.

Materials and Methods

Estimation and evaluation of virtual embolic area

- The process of estimation and evaluation of VEA was as follows.

1. Non-selective CBCT during hepatic arteriography (CBCTHA) data were transferred to the workstation.

FUJIFILM
Value from Innovation

2. Liver parenchyma were extracted manually because CBCT data cannot be used for automatic extraction, unlike CT data [5].

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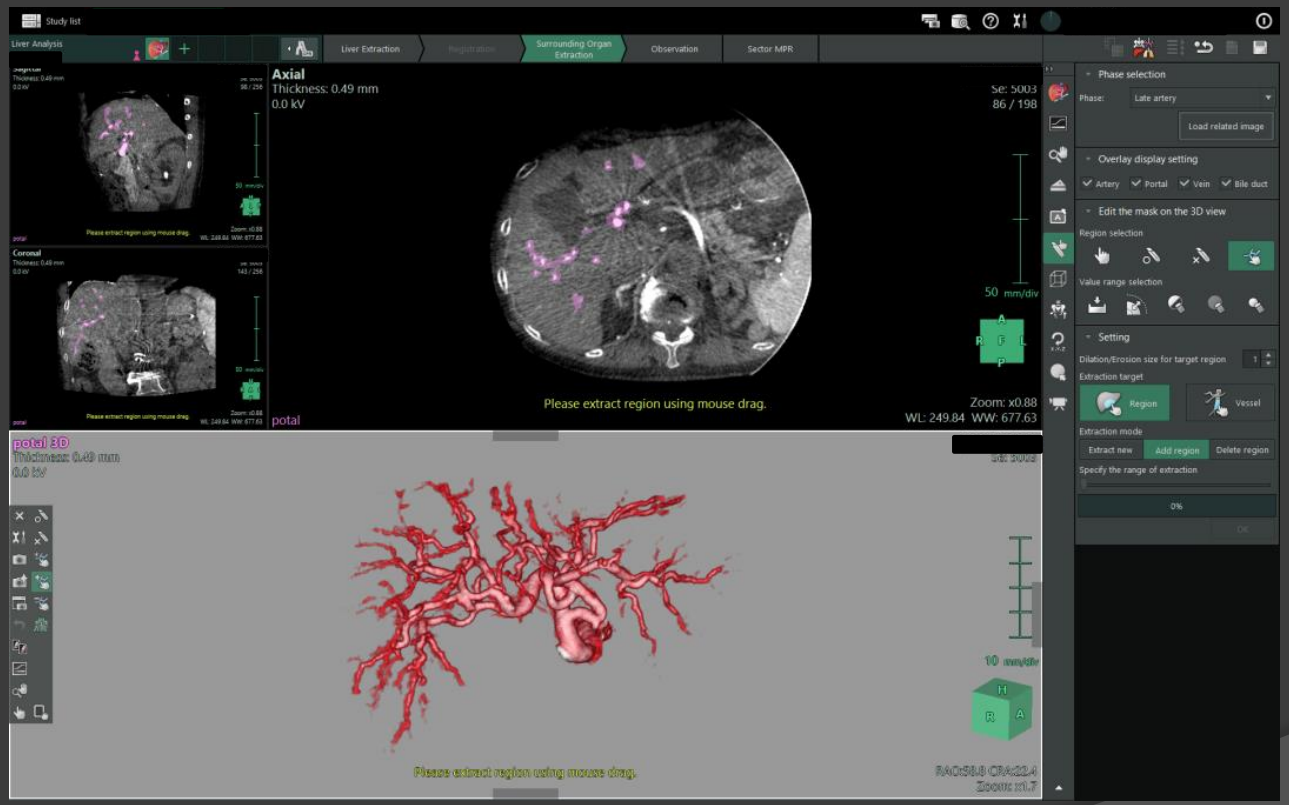
3. Major hepatic arteries were extracted manually, in addition to minor ones extracted. Eventually, volume rendering of the hepatic arteries was created.



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4. A simulated injection point for each tumor feeder was selected via the 3-D arteriogram extracted from non-selective CBCTHA with reference to spot radiographs obtained during cTACE.

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4. A simulated injection point for each tumor feeder was selected via the 3-D arteriogram extracted from non-selective CBCTHA with reference to spot radiographs obtained during cTACE. VEA images were obtained in a few seconds.

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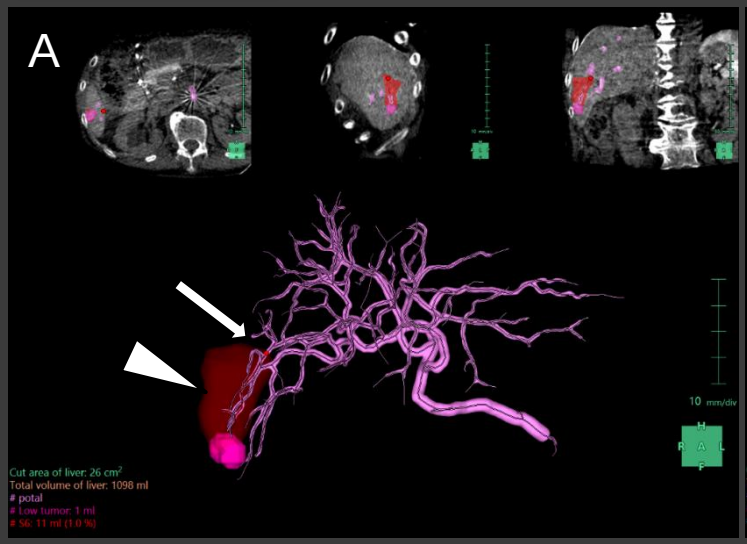
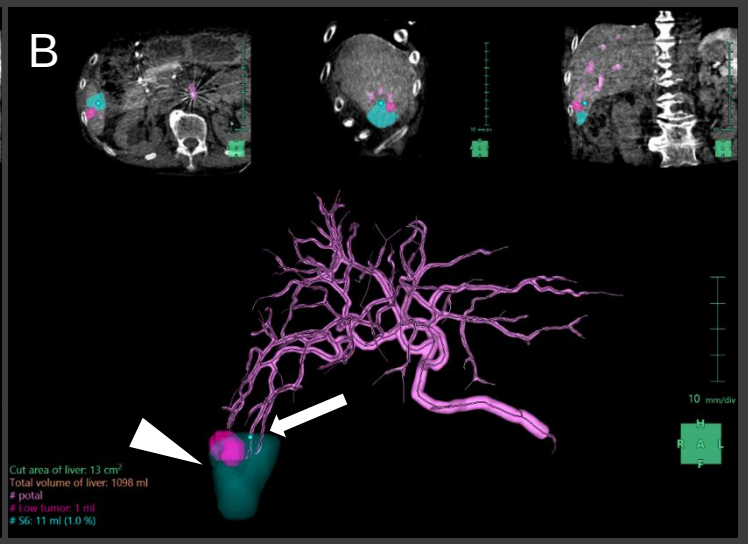
Case

An 81-year-old female with HCC in S6.





- There were three feeding arteries for HCC (purple sphere) (A, B, C).
- The virtual injection points (solid arrows) of the first, second and third feeding arteries are shown in red (A), blue (B), and green (C), respectively.
- The virtual embolic areas (VEAs) are the translucent areas (solid arrowheads) shown in red (A), blue (B), and green (C) respectively on the 3-D images and on the multiplanar images in the upper part of each figure.

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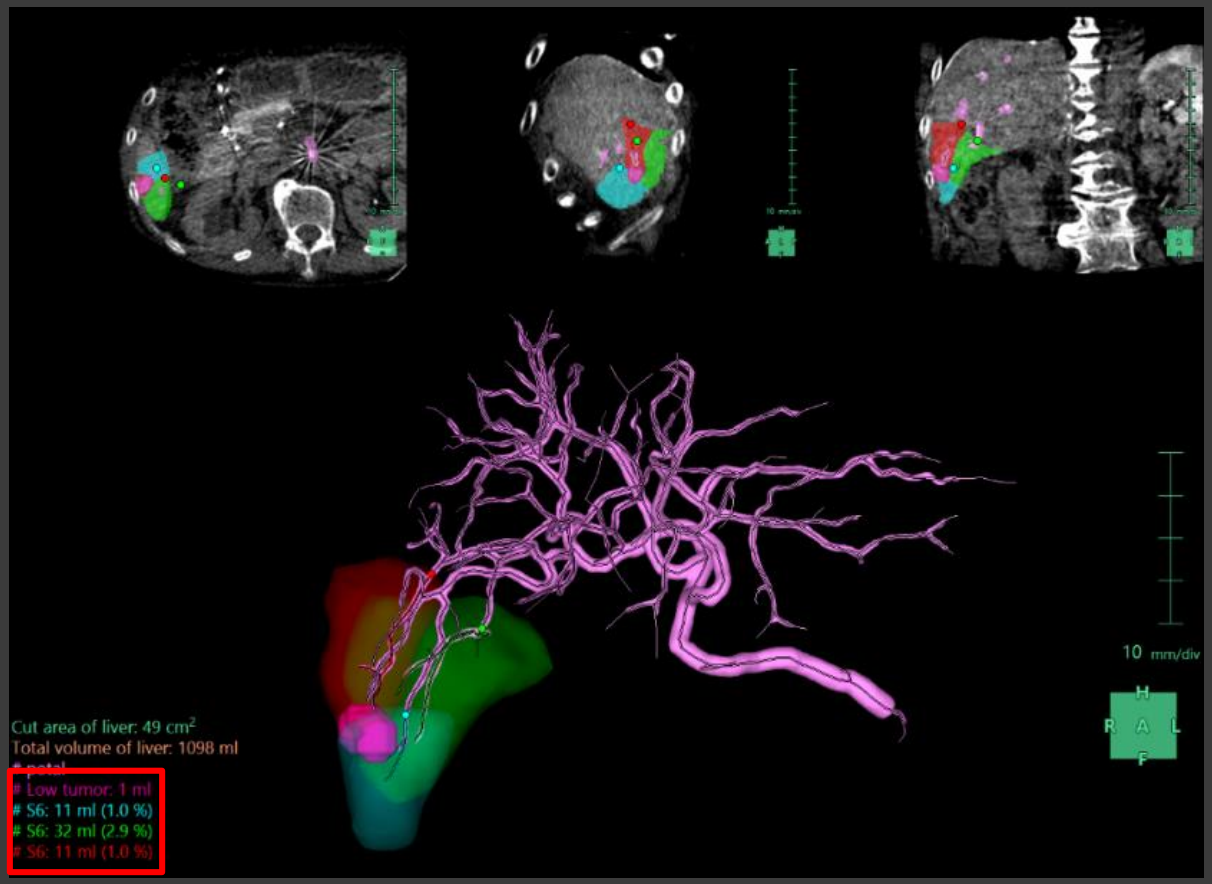
Case

An 81-year-old female with HCC in S6.



- The total VEA is shown in one figure, with each volume of the VEA in the lower left of the figure.
- The total processing time required from the time the CBCT image was available to the user to completion of estimation of VEA was about 30 minutes.

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Materials and Methods

Statistical analysis

- Intraclass correlation coefficients (ICCs) and Bland-Altman plots were used to evaluate agreement between the volume and cross-sectional areas in three orthogonal directions (axial, coronal and sagittal) between VEA and mREA.

- The ICC value was interpreted as follows [10]:
  - <0.40, poor agreement
  - 0.40-0.59, fair agreement
  - 0.60-0.74, good agreement
  - >0.74, excellent agreement

Results

ICCs for volume and cross-sectional area between mREA and VEA Group A

Parameter	ICC	95% Confidence Interval	
		Lower bound	Upper bound
Volume	0.97	0.94	0.99
Cross-sectional area			
axial	0.94	0.88	0.97
coronal	0.95	0.90	0.98
sagittal	0.87	0.75	0.94

ICC: intraclass correlation coefficients, mRAE: mean real embolic area,
VEA: virtual embolic area

Results

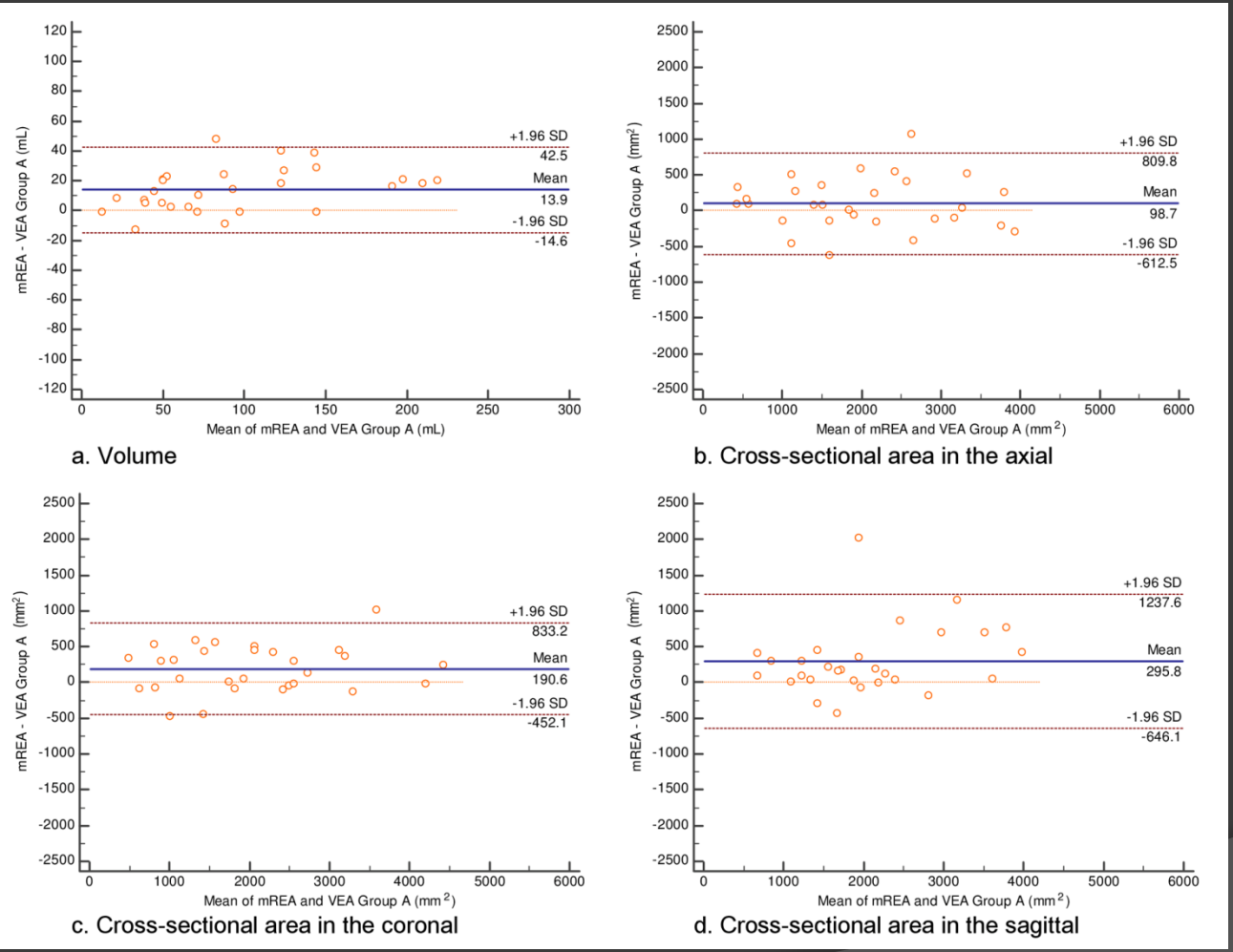
ICCs for volume and cross-sectional area between mREA and VEA Group B

Parameter	ICC	95% Confidence Interval	
		Lower bound	Upper bound
Volume	0.88	0.77	0.94
Cross-sectional area			
axial	0.88	0.77	0.94
coronal	0.83	0.68	0.92
sagittal	0.74	0.52	0.87

ICC: intraclass correlation coefficients, mRAE: mean real embolic area,
VEA: virtual embolic area

Results

Bland-Altman plots show agreement between mREA and VEA Group A.



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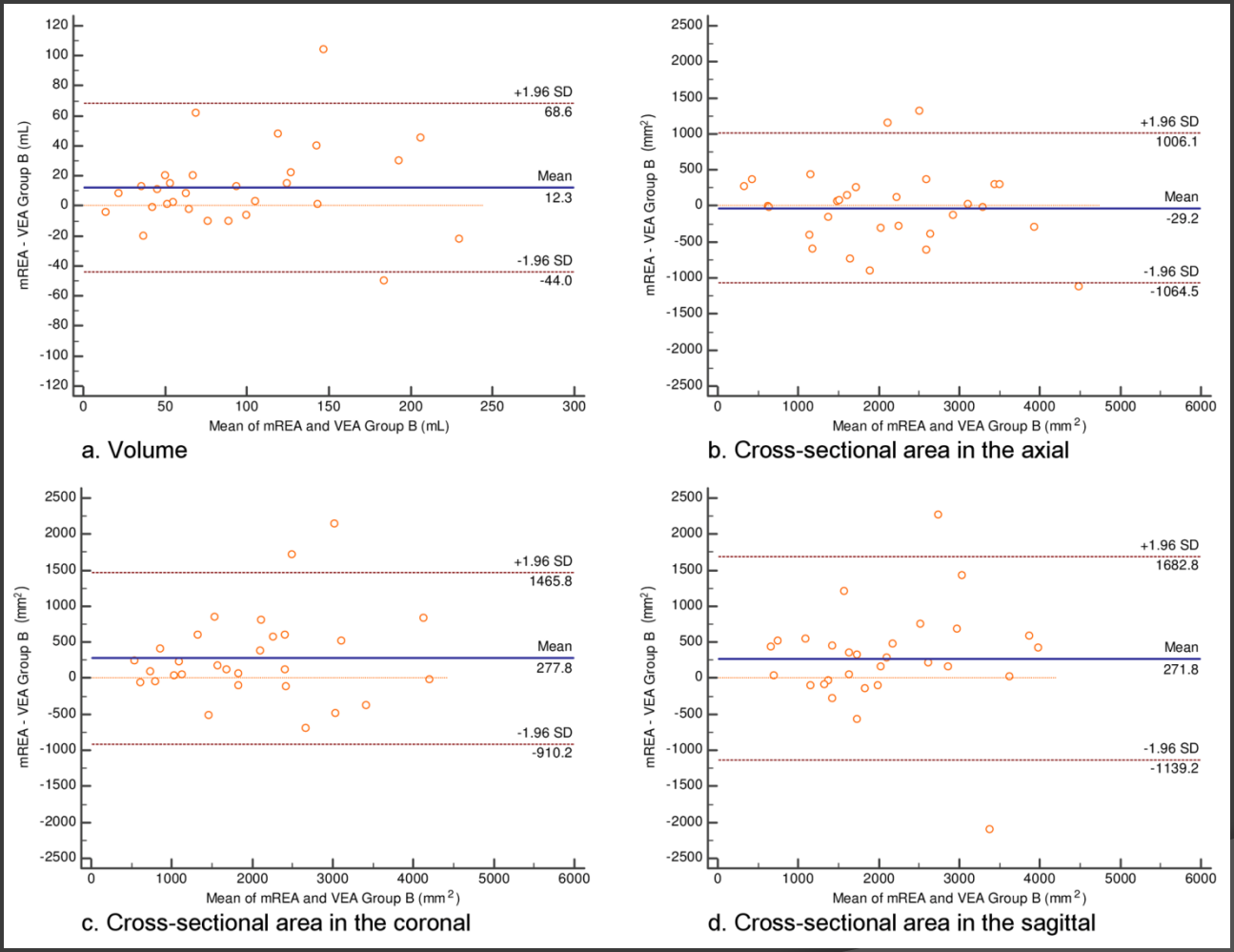
Results

Bland-Altman plots show agreement between mREA and VEA Group B.



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Results

- The ICCs for volume and cross-sectional area between mREA and VEA showed excellent agreement, except for the sagittal plane in group B, which was classified as good agreement.
- Moreover, the lower bounds of the 95% CI indicated excellent agreement, except for the coronal and sagittal planes in group B, which were in good agreement.
- Bland-Altman plots between VEA and mREA for volume and cross-sectional area showed no systematic biases.

Discussions ①

- If the vascular territory of tumor-feeding arteries can be determined before chemoembolization, the optimal catheter position including the whole tumor and the safety margin for chemoembolization can be determined with reference to VEA.

- Moreover, it may contribute to the therapeutic effects, reduce side effects and the preservation of liver reserve, because it is possible to intensively inject more anticancer drug- iodized oil emulsion into the tumor and safety margin and to reduce its distribution and embolic area to normal liver parenchyma. In addition, reference to VEA may contribute to decreases in radiation exposure, contrast medium and procedure time.

Discussions ②

- A great improvement in estimating the virtual parenchymal perfusion area is required for practical clinical use. Shortening of the time required to prepare a simulation is needed. Customization of the workstation made it possible to create VEA in about 30 minutes. Automatic extraction of liver parenchyma and hepatic arteries from CBCT data would shorten this time to less than half, in addition to improving accuracy and standardizing results.

- In conclusion, VEA based on CBCT data using a commercially available 3-D workstation and liver analysis software in cTACE can be displayed using color coding and clear divisions, and VEA showed good agreement with REA retrospectively. This method can be useful for estimating the embolic area in cTACE.

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