Phase Characteristics in Phase Contrast Method

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Background

Endothelial cell and smooth muscle cell respond to the mechanical circumstances around them.

Shear stress (on endothelial cell): blood flow

Stress (in vessel wall): shape

Background
-Phase Contrast Method (1)-

Phase contrast method is imaging sequence in MRI, which is used for measuring the velocity *in vivo*.

- The method is based on gradient echo method.
- The phase is proportional to the velocity.

Background
-Phase Contrast Method (2)-

- The measurement accuracy (phase) gets worse when the dephasing occurs.

- The influences of sequence parameters has not been clarified well.

Purpose

Phase characteristics were examined by the sequence parameter influences.

1. Measurement Accuracy (without dephasing effect)
2. Flow profile (including dephasing effect)
3. Static field (without dephasing effect)

Material & Method

Corresponding to the component ratio change of blood.

- *Sample* :
  $MnCl_2$ solution (0.005 mM – 0.2 mM)
- *Evaluation of the relaxation times* :
  inversion recovery method (T_1), spin echo method (T_2), gradient echo method (T_2*)
- *Influences of the sequence parameters* :
  TR, TE, VENC, and oversampling direction.

All the experiments has been performed with 1.5 T MR system ExcelArt (Toshiba cooperation, Japan).

Result 1-1
- Sequence parameter influences in the accuracy -

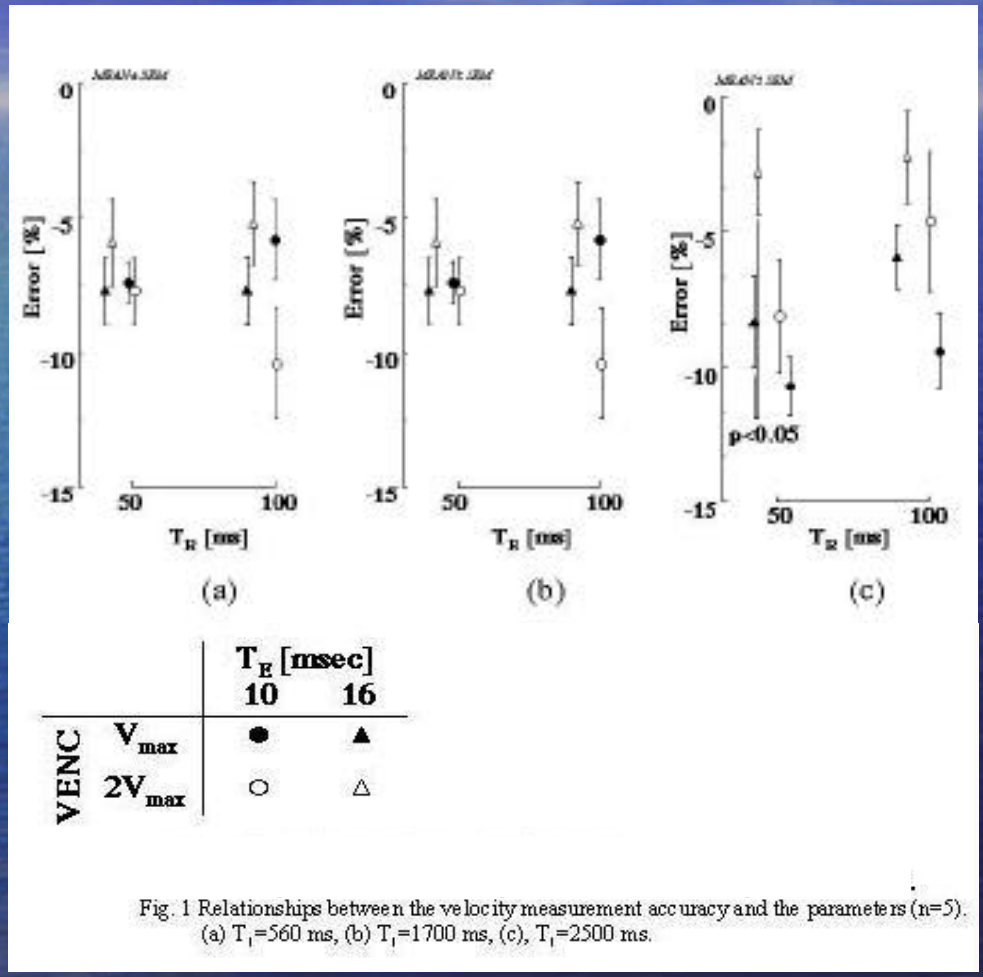


Fig. 1 Relationships between the velocity measurement accuracy and the parameters (n=5).
(a) T_I=560 ms, (b) T_I=1700 ms, (c), T_I=2500 ms.

(Kato Y and Himeno R: Evaluation of the Velocity Measurement Characteristics of Phase Contrast Method for Developing a Region Extraction Method for Blood Vessels from MRI images, Transactions of the Japanese Society for Medical and Biological Engineering, 41(2), 115-121, 2003.)

Result 1-2

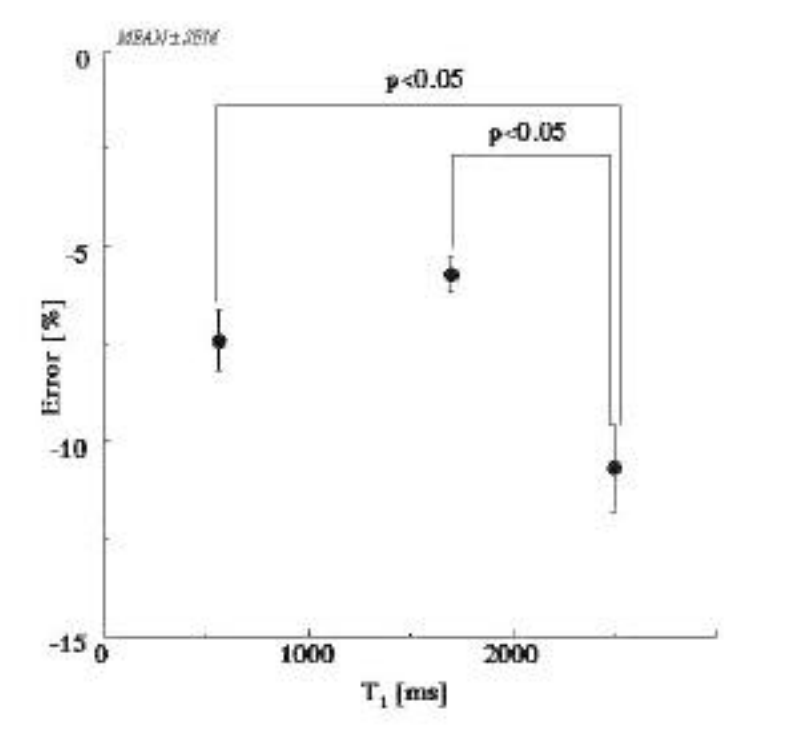


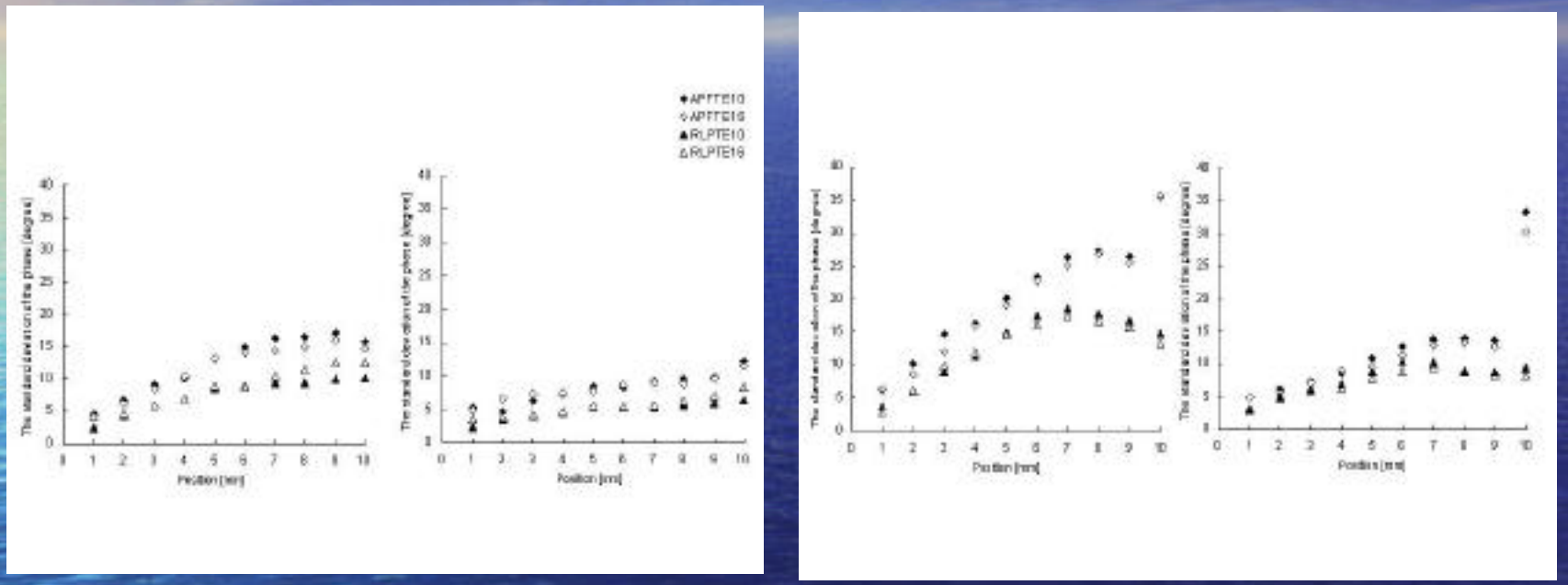
Fig. 2 Relationship between the velocity measurement accuracy and relaxation time T1 (n=5). T_R=50 ms, T_E=10 ms, and VENC is the nearest integer to the maximum velocity.

(Kato Y and Himeno R: Evaluation of the Velocity Measurement Characteristics of Phase Contrast Method for Developing a Region Extraction Method for Blood Vessels from MRI images, Transactions of the Japanese Society for Medical and Biological Engineering, 41(2), 115-121, 2003.)

Conclusion (1)

The measurement accuracy could be influenced by the sequence parameters.

Result 2-1
- velocity profile and sequence parameters-



(A) (B) (C) (D)

Fig. 3 Relationship between the distance from the center and the standard deviation of the flow velocity. TR=50 ms; AP, anterior – posterior; RL, right – left; F, frequency oversampling; P, phase oversampling; TE=T_E. (A) T_1=6.7x102 ms, T_2*=6.4x10 ms, VENC=15 cm/s, (B) T_1=6.7x102 ms, T_2*=6.4x10 ms, VENC=30 cm/s, (C) T_1=1.8x103 ms, T_2*=3.6x102 ms, VENC=15 cm/s, (D) T_1=1.8x103 ms, T_2*=3.6x102 ms, VENC=15 cm/s,

(Kato Y and Himeno R: Velocity Profile Characteristics of the Phase Contrast Method for Estimating Flow in a U-Shaped Tube, Transactions of the Japanese Society for Medical and Biological Engineering, 41(4), 306-313, 2003.)

Conclusion (2)

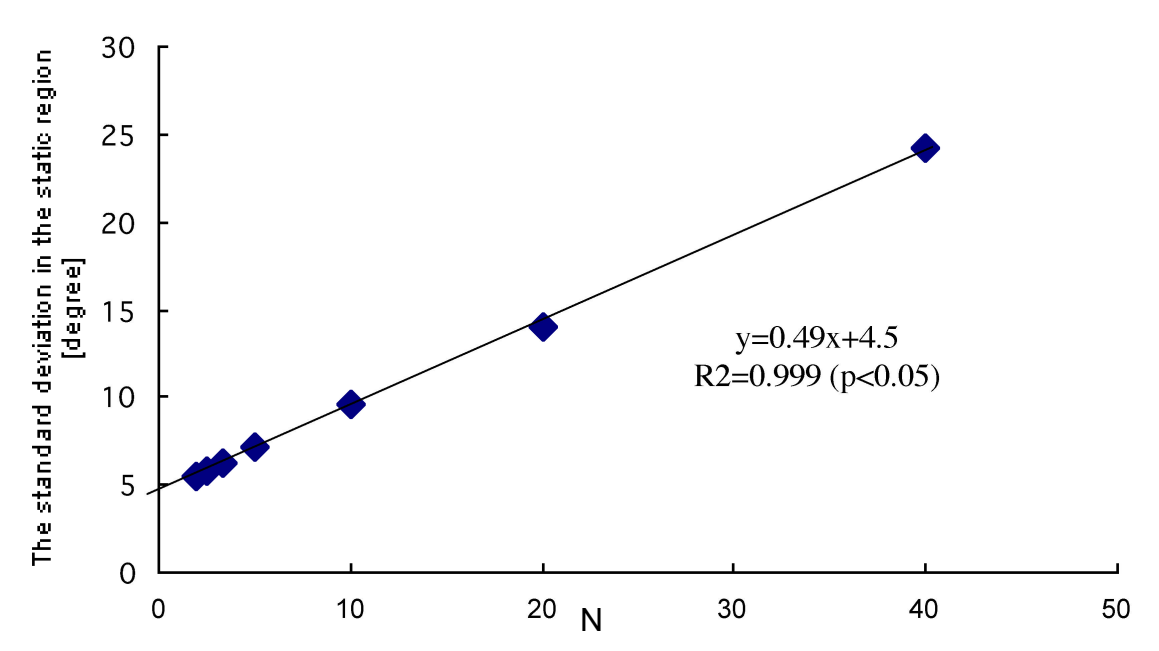
The influences of the sequence parameters could be related to the dephasing.

Result 3-1

In each parameter set,

- The mean of phase: not constant
- The standard deviation of the phase: constant

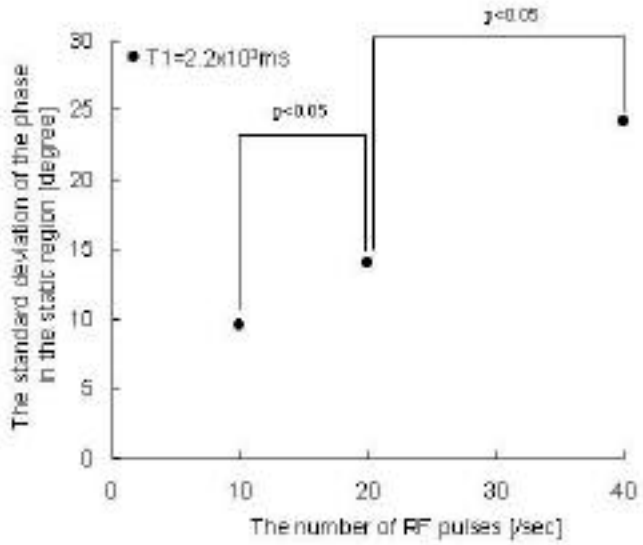
Result 3-2
- Energy and Phase Distribution-



Relationship between the standard deviation of the phase and the number of RF pulse. T_1=2.2x10^3 ms, T_2=1.1x10^3 ms, T_2*=7.1x10^2 ms. N, the number of RF pulse.
(JSMRM 2003, Yamanashi)

Result 3-3

-Heterogeneity and the Amount of Energy-



Relationship between the standard deviation of the phase in the static region and the number of RF pulse.

Result 3-4

- Segmentation Method using the Phase Characteristics-

(Kato Y and Himeno R: Evaluation of the Velocity Measurement Characteristics of Phase Contrast Method for Developing a Region Extraction Method for Blood Vessels from MRI images, Transactions of the Japanese Society for Medical and Biological Engineering, 41(2), 115-121, 2003.)

Conclusion(3)

- The standard deviation of the phase is useful for identifying the region of blood vessel.
- The energy of RF pulse could influence the distribution of the phase.