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
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

• **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 -

Result 1-2

Fig. 2 Relationship between the velocity measurement accuracy and relaxation time $T_1$ ($n=5$). $T_R=50$ ms, $T_E=10$ ms, and VENC is the nearest integer to the maximum velocity.

Conclusion (1)

The measurement accuracy could be influenced by the sequence parameters.
Result 2-1
- velocity profile and sequence parameters-

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=6.7x10^2 ms, T_2^*=6.4x10 ms, VENC=15 cm/s, (B) T_1=6.7x10^2 ms, T_2^*=6.4x10 ms, VENC=30 cm/s, (C) T_1=1.8x10^3 ms, T_2^*=3.6x10^2 ms, VENC=15 cm/s, (D) T_1=1.8x10^3 ms, T_2^*=3.6x10^2 ms, VENC=15 cm/s,

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.

$T_1 = 2.2 \times 10^3$ ms, $T_2 = 1.1 \times 10^3$ ms, $T_2^* = 7.1 \times 10^2$ 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-

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.