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Letter to the Editor

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# Pulse Transit Time between Fetal Left Ventricle Outlet and Umbilical Cord Insertion: Feasibility and Technical Considerations

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Dear Editor,

Pulse transit time (PTT) is measured as the time interval difference between the R wave on an electrocardiogram and the increase in the pulse wave in the peripheral artery. The pulse wave velocity (PWV) is calculated according to the PTT and has been used to diagnose arteriosclerosis for many years. It is currently used as a prognostic prediction tool for cardiovascular disease [1, 2]. Because PTT is affected by blood pressure [3], its usefulness as an indicator of blood pressure fluctuations during cardiovascular and emergency surgical procedures has been reported [4]. Although PTT is measured for adults in many clinical circumstances, there are no reports regarding the use of PTT in fetus. Therefore, in this view, we aimed to measure fetal PTT using dual-gate Doppler.

Dual-gate Doppler is a novel tool that makes it possible to measure the Doppler waveform at different sites simultaneously. The possibility of using this technology to assess fetal cardiac function has been reported [5, 6]. To measure fetal PTT, we measured the time interval difference between the waveform obtained at the left ventricular outlet tract (LVOT) and the waveform obtained at the umbilical cord insertion (CI) to the placenta. As there are no reports on measuring the time interval difference of pulse waves between 2 different sites in the fetal circulation, it was difficult to exactly determine which pulse wave at the LVOT was comparable to the pulse wave at the CI during the normal sinus rhythm. Therefore, we decided to measure PTT in cases of arrhythmia to match the combination waveform at the LVOT to that at the CI. Ultrasound examinations were performed using an Arietta 70 machine (Hitachi Health Care Systems, Tokyo) equipped with a curved linear transducer.

In case 1, PTT between LVOT and CI was 124–128 ms at 28 W-6D (shown in Fig. 1a).

In case 2, PTT between LVOT and CI was 124–144 ms at 29 W-1D (shown in Fig. 1b).

In case 3, PTT between LVOT and CI was 100–108 ms at 35 W-3D (shown in Fig. 1c).

PTT between LVOT and CI ranged from 100 to 144 ms in these cases. Aortic PWV in young children has been reported as 4.3 ± 0.4 m/s [7]. Considering the distance from LVOT to umbilical ring and the umbilical cord length, the PTT value in the current case series is not inconsistent with those reported in young children [7]. If the fetal heart rate is within the normal range (110–160 bpm), the beat-to-beat time interval is 375–545 ms. As the PTT between LVOT and CI is not thought to be larger

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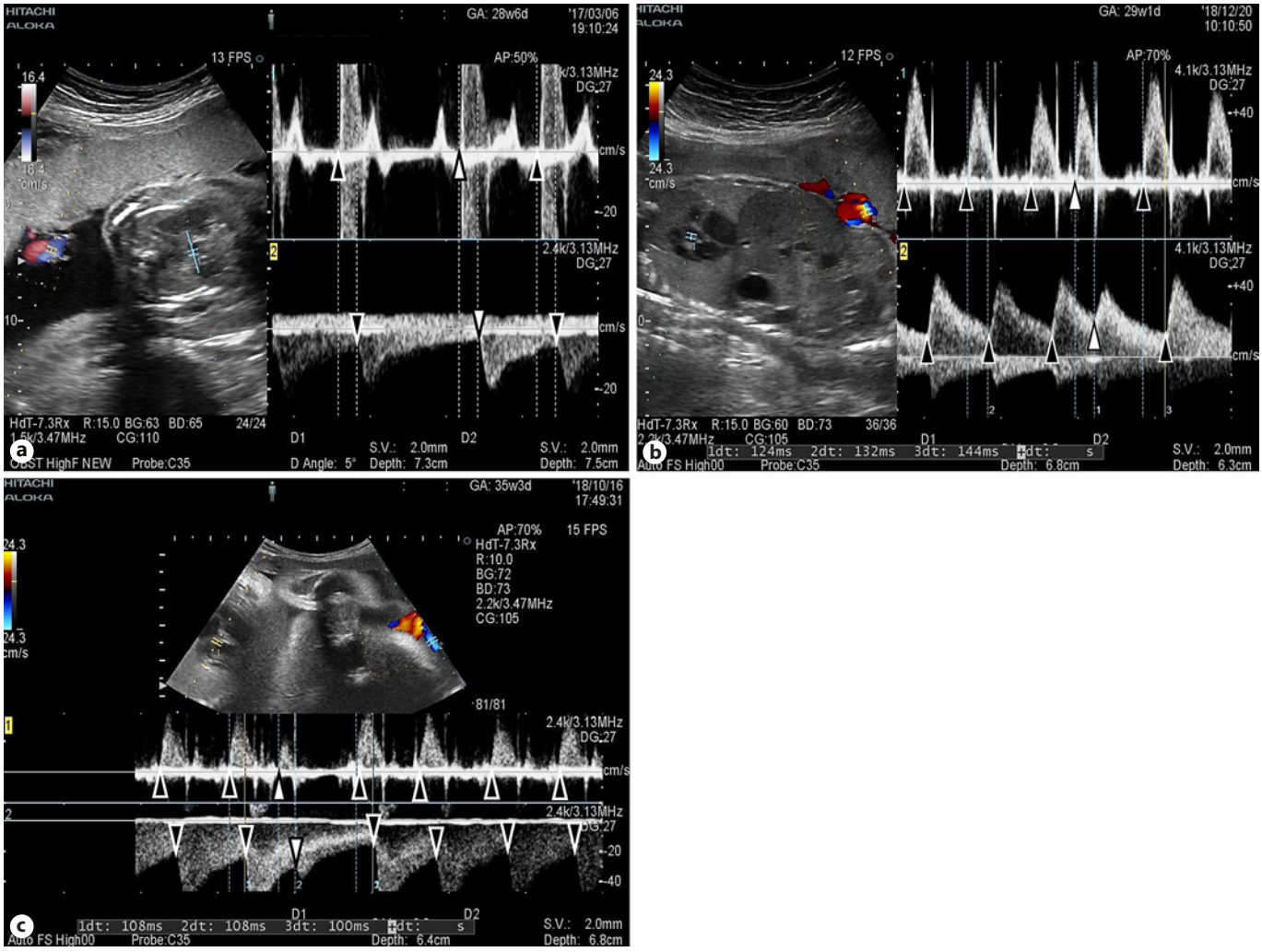


**Fig. 1.** Dual-gate Doppler pulse wave in the arrhythmia cases. The upper lane indicates the pulse waves at the LVOT. The lower lane indicates the pulse waves at the umbilical CI to the placenta. The black arrows indicate the pulse waves of the regular pulse, and the white arrow indicates the pulse waves of the arrhythmia. The time interval difference between LVOT and CI was 100–144 ms. LVOT, left ventricle outlet tract; CI, cord insertion.

than the beat-to-beat time interval, PTT can be obtained by measuring the time interval between 2 adjacent waveforms. PTT is determined by the distance between 2 points within the circulatory system, and PWV is calculated according to the PTT. PWV is affected by fluid density, vascular diameter, and vascular elasticity. PTT between LVOT and CI is thought to be affected by fetal growth, umbilical cord length, fetal anemia, and fetal blood pressure. PTT measurement has also a limitation. As the PTT value is affected by various factors, it may be difficult to judge the fetal status by PTT alone. However, it may be possible to estimate umbilical cord length and/or fetal anemia by considering gestation age, fetal growth, and so on. It may also be possible to estimate the fetal blood pressure fluctuation by assessing the PTT changes over time in 1 fetus. Although fetal PTT is still preliminary, it may provide us novel information about the fetal environment and may offer insights into currently unresolved issues regarding fetal physiology and pathophysiology. This case series is the first to report about fetal PTT. Future research on the correlation between this index and fetal cardiovascular status in different fetal conditions could provide novel insights for research or clinical practice.

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## Conflict of Interest Statement

The authors have no conflicts of interest to declare.

## Author Contributions

Conception and design of study: Shigenori Iwagaki. Acquisition of data: Yuichiro Takahashi, Noriaki Imai, Rika Chiaki, Kazuhiko Asai, and Masako Matsui. Drafting the manuscript: Shigenori Iwagaki.

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