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Flow Visualization of the neo-sinus following transcatheter aortic valve implantation in an aortic valve model: pulsatile flow and pressure circulation system equipped with left and right coronary arteries

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***Abstract*— To visualization the flow of neo-sinus after aortic valve implantation, we created a new particle image velocimetry technique and pulsatile flow and pressure circulation system.**

***Clinical Relevance*—This research demonstrates that the eo-sinus of the transcatheter aortic valve's flow velocity distribution during the cardiac cycle is stationary at less than 0.1 m/s, making it even more prone to thrombosis.**

I. INTRODUCTION

The cause of thrombotic events in neo-sinus (the place between the transcatheter aortic valve's leaflet and the stent frame) after transcatheter aortic valve replacement are not well understood yet.

The aim of this research was to construct a pulsatile flow and pressure circulatory system with left and right coronary arteries and to examine the velocity distribution in the neo-sinus after transcatheter aortic valve (TAV) implantation in the native aortic-valve (NAV) model. To investigate the flow velocity in the neo-sinus, a novel experimental setup using particle image velocimetry (PIV) was devised.

II. METHODS

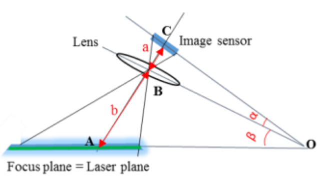

Fig. 2.1 Scheimpflug principle(On focus)

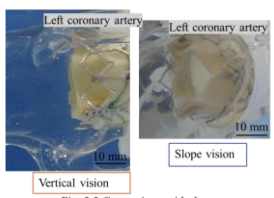

Fig. 2.2 Comparison with the Vertical and Slope vision

$$\alpha = \tan^{-1}\frac{113.76}{336.24 \times \tan(90° - \beta)} \quad (\alpha \leqq 20)(2.1)$$

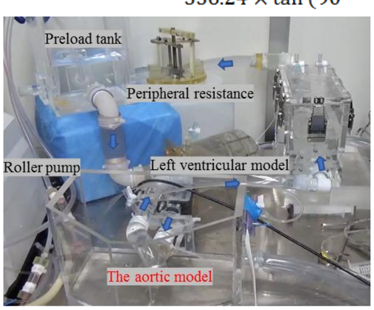

Fig. 2.3 View of circuit

(1) PIV was used to visualize the flow through the neo-sinus. As shown in Figs. 2.1 and 2.2, the neo-sinus cannot be visualized using conventional PIV methods. Thus, we utilized the Scheimpflug principle to calculate the optimal optical conditions for capturing the neo-sinus on the slope (Equation 2.1).

(2) To investigate the impact of depth of field, a simulated TAV model was created and the angle (β) and distance (a+b) were determined at the greatest possible shooting range.

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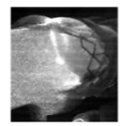
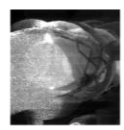
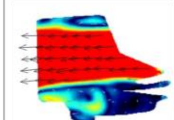
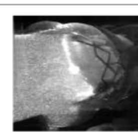
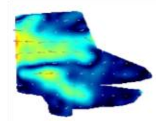
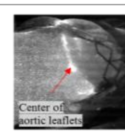
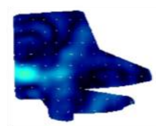
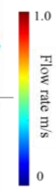
(3) We developed a pulsatile circulatory system with both systemic and coronary circulations. In the pulsatile circulation system, the Sapien XT TAV (Edwards Lifesciences) was implanted. The left and right coronary arteries were 4/4.5 mm [2]in diameter. The flow visualization tests were performed with a mean aortic flow of 3 L/min and the mean aortic pressure of 100 (120/80) mmHg. The heart rate was set to 70 beats per minute. The mean left and right coronary flow are 160 mL/min [3], and 80 mL/min.

III. RESULTS

Table 3.1 Flow fields in Neo-sinus of the transcatheter aortic valve

	Particle movie	Speed vector
T_0		
T_1		
T_2		
T_3		



(T_0=0.00s, T_1=0.138s, T_2=0.352s, T_3=0.500s)
The flow visualization of Neo-sinus is shown in Table 3.1

IV. DISCUSSION & CONCLUSION

(1) From this study, we constructed a test system that can visualize 53.3% of the Neo-sinus, which could not be visualized before.
(2) The visualization of the Neo-sinus showed that the velocity error between slope and vertical was within 2.7%, indicating the effectiveness of the novel imaging method.
(3) The mean flow velocity through the right coronary sinus was 0.101 m/s during diastole, showing that the valve interior was stagnant.

REFERENCES

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