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A Study on a Newly Designed Aortofemoral Prosthetic Y Graft

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Aortofemoral prosthetic Y grafts are applied for treating abdominal aortic aneurysms. In this study, experiments were conducted in order to demonstrate the effects of an incremental increase in branch diameter in a newly designed aortofemoral Y graft under conditions of both steady and pulsatile flow conditions. It was revealed that in Y grafts, the incremental increase by only 4 mm in the branch diameter affects hydrodynamic characteristics drastically under conditions of both steady and pulsatile flow conditions.

Keywords: aortofemoral prosthetic Y graft, mock circuit, bifurcation, pulsatile flow, steady flow

1. Introduction

Aortofemoral Y grafts are applied commonly for treating of abdominal aortic aneurysms which are at a high risk of rupture. Typically in these Y grafts, the diameter of the stem conduit is 16 mm and that of the branch conduit is 8 mm (Fig. 1). The ratio of the stem to the branch conduit diameters is different from that in the native bifurcation anatomically. It is pointed out that the branch diameter is too small to allow these graft implants to work effectively. Consequently, new grafts with a 9-mm branch diameter have been recently implemented in clinical applications. In this study, experiments were conducted in order to demonstrate the effects of an incremental increase in the branch diameter in a newly designed aortofemoral Y graft under conditions of both steady and pulsatile flow conditions.

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(a) Conventional graft (b) Newer graft

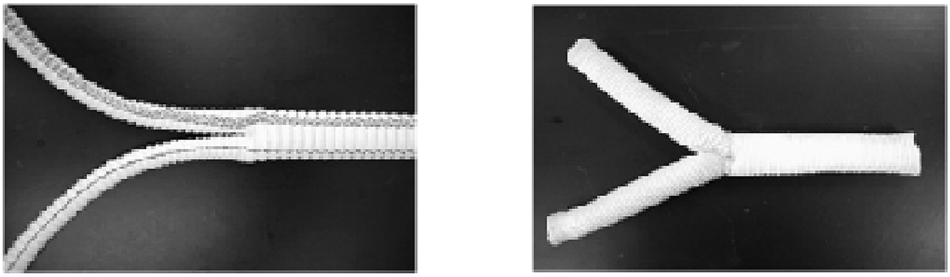

Fig. 1. Photographs of aortofemoral Y grafts

2. Method

Two types of models of rigid aortofemoral Y grafts were made from epoxy (Fig. 2). There are one inlet and two outlets in the bifurcation models. Correspondingly, the conduit of the inlet end is called the stem and conduits of the outlet ends are called the branches. One model, in which the stem diameter is 16 mm and the branch diameter is 8 mm, replicates conventional grafts. In the other, which replicates the newer graft, the branch diameter is 12 mm and the stem diameter is the same as in the conventional graft. Each model was installed in a test circuit (Fig. 3), in which physiological saline could be fed through the graft. Pressure and flow rate at the inlet and the outlets of the models were measured under steady flow conditions. In addition, each model was installed in a mock circuit as shown in Fig. 4, in which physiological saline was fed through the graft. Pressure and flow rate at the inlet of each model were measured by a pressure transducer (PGM-1KG, Kyowa Dengyo Ltd., Tokyo) and an electromagnetic flow meter (FF-200T, Nihon Kohden Ltd., Tokyo) under conditions of pulsatile flow.

(a) Conventional graft (b) Newer graft

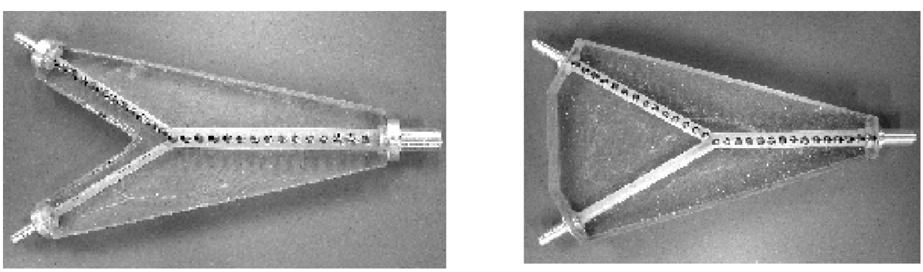

Fig. 2. Two types of models of rigid aortofemoral Y grafts

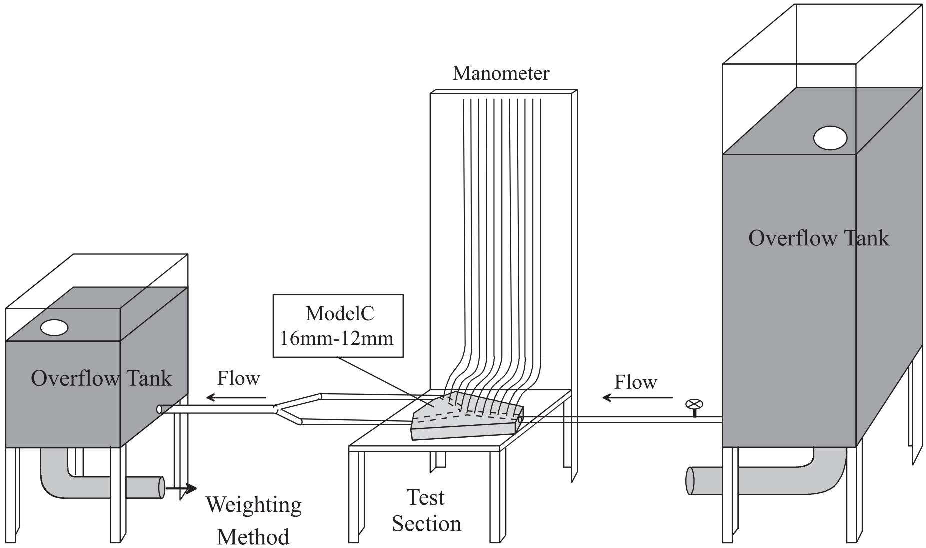

Fig. 3. Test circuit used for steady flow study

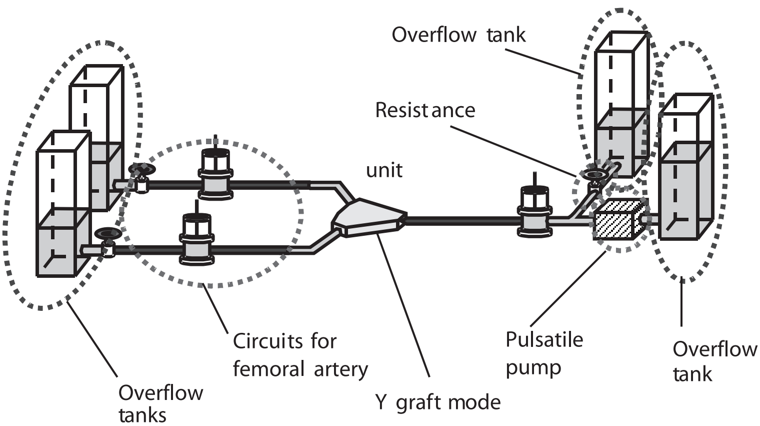

Fig. 4. Test circuit for pulsatile flow experiments

3. Results and Discussion

3.1. Steady Flow Condition

Under the steady flow conditions, the pressure gradient between the inlet and the outlets was 1 mmHg in the case of the newer graft, which was lesser by 4 mmHg than that of the conventional graft at Reynolds number 5000 (Fig. 5). In the newer graft model, the coefficient of pressure loss due to bifurcation, calculated on basis of the pressure and flow rate measurements for the graft models, was less than half of the coefficient found in the conventional graft model (Fig. 6) [1].

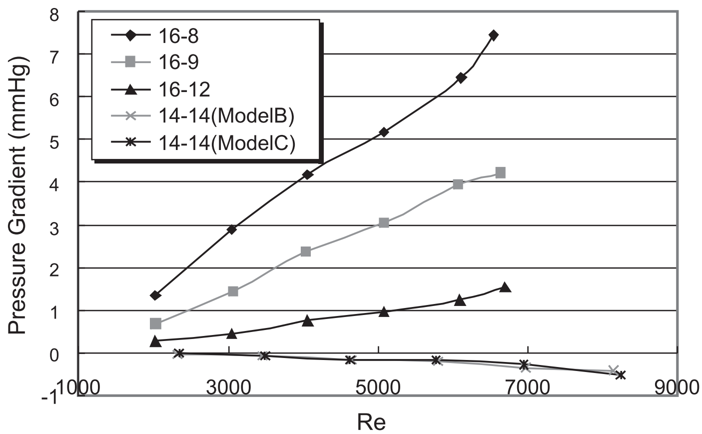

Fig. 5. Pressure gradients at each Reynolds number

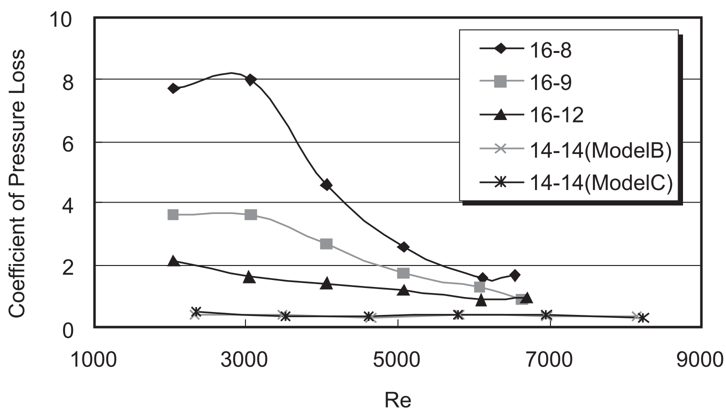

Fig. 6. Coefficients of pressure loss at each Reynolds number

3.2. Pulsatile Flow Condition

The mean flow rate at the inlet was 1.0 liter/min for the conventional graft model with the input impedance of the femoral artery being 1.0×10^4 dyne·sec/cm^3 at 0 Hz in the mock circuit. In the newer model, the flow rate was increased by 0.2 liter/min under the same conditions of pulse pressure with the mean pressure being 66 mmHg, as with the conventional graft model as shown in Fig. 7 [2]. When the input impedance was increased up to 3.0×10^4 dyne·sec/cm^3 by regulating a resistant unit in the mock circuit, the results were the same as those with the impedance being 1.0×10^4 dyne·sec/cm^3.

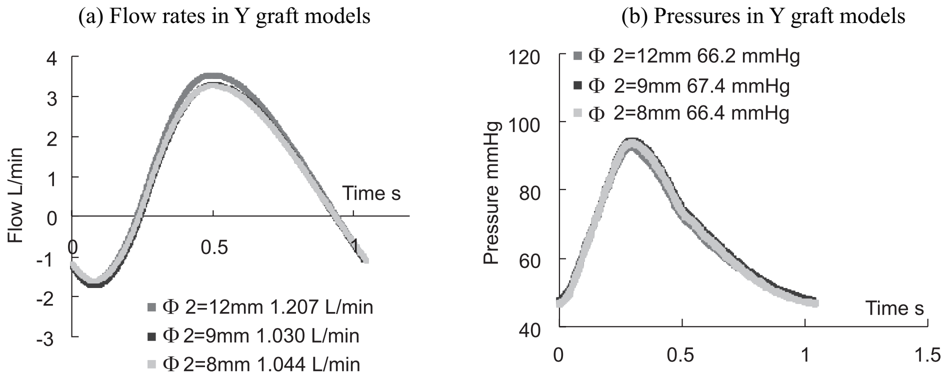

Fig. 7. Results of pulsatile flow experiments

4. Conclusion

Variation in the branch diameter in the aortofemoral Y grafts was evaluated from the standpoint of hydrodynamics in epoxy-based models. It was found that in Y grafts, the incremental branch diameter increase by only 4 mm affects hydrodynamic characteristics drastically under conditions of both steady and pulsatile flow conditions. Comparing these results with clinical data, we will try to design a new graft that can be effectively used as implant.

References

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