End-to-End Anastomosis Using Improved Stent Graft

1Yu-Chieh Tseng, 1,2,3Chien-Chang Chen and 1Min-Long Yeh
1Institute of Biomedical Engineering, National Cheng Kung University, Taiwan
2Chi Mei Medical Center Cardiovascular Surgery, Taiwan
3Chia Nan University of Pharmacy & Science, Taiwan
Email: mlyeh@mail.ncku.edu.tw

SUMMARY
In order to overcome the problems of suture method in vessel anastomosis, many non-suture methods have been designed; however, they still have their limits and drawbacks in limited in smaller vascular and destruction on vessel wall. The purpose of this study is to investigate the direct sutureless end-to-end anastomosis by using stent graft. An ex-vivo experiment was conducted to evaluate the oversizing effect on water leakage.

So far, the ex vivo preliminary results showed that there was less related between flow rate and water leakage. Besides, the water leakage was observed under different pressure: (A) the water leakage at 130mmHg was 8.23, 5.04 and 3.12ml/min · cm² for the 3, 4 and 5cm landing zone groups respectively; (B) almost no leakage was found when outer 3mm band was applied. This result could suggest that the longer landing length can increase the contact area of vascular graft and porcine aorta wall, and the leakage will be decreased. In addition, there was almost no leakage on the anastomotic site, from which we can suppose that the banding with Dacron has the function of fixation.

INTRODUCTION
The most common chronic aorta disease is aortic aneurysm, which is caused from atherosclerosis and result in the expansion of aortic diameter. Traditionally, therapy of aortic aneurysm is to cut the section of blood vessel with aneurysm and the lost vessel part was replaced with graft by needle suture, which was first successfully completed in 1902 by Alexis Carrel[1]. However, there are some critical suture technical problems discussed from surgeons, such as needle hole bleeding, time consuming, and uneven suture distances.

To overcome these difficulties, some non-suture anastomosis for vascular anastomosis have been designed including ring, stents, staples, tubes, clips, adhesives and welding[2], but they still have their limitations. In order to reduce the complications of non-suture anastomosis, the fixation of devices is important, which includes graft diameter size and drag force. For graft, the appropriate diameter size is suggested that 10-20% oversizing seems to be the safe choice on clinical operation[3]. In the other hand, the paper showed that with a larger graft diameter and graft placement near aorta arch was bore up the maximum drag force. Nevertheless, there were some approaches to reduce the drag force, which lengthened the landing zone of stent graft and fixed end site of stent graft by hook[4].

There isn’t any ideal sutureless device to efficiently perform anastomosis in clinical operation up to now. Therefore, this study designed the device with two stainless stents sewn into the end of the vascular graft for aortic anastomosis. This study conduct the ex vivo end-to-end anastomosis with porcine aorta and the water leakage from the anastomosis was observed. The security of this stent graft into aorta could be evaluated by the amount of water leakage.

METHODS
The internal diameter of 14mm and straight 12cm commercial graft was chosen in this experiment. The stainless steel stents, with the height of 22mm and the diameter of 44mm and 36mm respectively, were sutured at 3cm and 5cm of the front graft on one end.

Both ends of the stent graft and porcine aorta were connected to the roller pump, and the intraluminal pressure was gradually increased by using vascular forceps which clamped the tube near pressure monitor. In this flow system, saline was used as perfusion fluid and the amount of leakage from the anastomosis was collected in one minute (Figure 1).

**Figure 1:** Schematic representation of ex vivo experiment model

There were two parts of ex-vivo experiments.
(A) The front stent graft was divided into five regions with 1 cm distance. The 3, 4, and 5cm landing regions were put in the porcine aorta in order to observe the saline leakage from this anastomosis in one minute.
The landing zone between the stent graft and porcine aorta was fixed on 5cm region. One group was banded with 3cm wide Dacron on the anastomotic site and the other was no banded. When the leakage of no banding group was observed, the external diameter of distal aorta was measured in the same time.

RESULTS AND DISCUSSION
The water leakage was less related to flow rate but it had positive relationship with water pressure (Figure 2). The leakage increased with the raising of interluminal pressure on 3, 4, 5cm landing zone. When the pressure was fixed at a value, such as 130mmHg, the water leakage on 5cm was the least among three groups (Figure 3).

To measure the water leakage of single graft from hydrostatic pressure to 93mmHg, the leakage increased; In contrast, the water leakage became less obviously. Because of coating gelatin on the graft vascular, the graft enhanced water resistance and prevented blood leakage after soaking in the water.

The reality water leakage of no banding group was obtained from subtracting the leakage of single graft group. It was because that we had to exclude the leakage factors from graft. The results showed that the leakage had a tendency to increase. Otherwise the reality water leakage of banding group was obtained with the same method. The value was regarded as zero if the subtracting value was negative. Even though the leakage was increase with the pressure, but after subtracting the factor of graft, the values were negative. In the other words, there was no leakage on the anastomotic site.

Comparison of the water leakage between banding and no banding was obviously observed that the leakage of no banding group was more than banding group (Figure 4). In vivo, the surrounding tissue of vascular support the arteries and then the changes in diameter of aorta can be limited[5]. The banding can make vascular graft and aorta inner wall attach completely. This is why the water leakage of banding group is less than no banding group.

Changes in diameter were biggest among the inner tube pressure of 60 to 80mmHg, which was also showed in reviewed paper[5]. When the pressure came to 120 mmHg, the slop of pressure and diameter tended to a gradual value (Figure 5).

CONCLUSIONS
These preliminary results could suggest that the longer landing length can increase the contact area of vascular graft and porcine aorta wall, and the leakage will be decreased. In addition, there was almost no leakage on anastomotic site, from which we can suppose that the banding with Dacron has the function of fixation.

ACKNOWLEDGEMENTS
The authors would like to thank for support from the Chi Mei Medical Center Animal Center.

REFERENCES