Comparison between Vascular Closure Stapler Clips and Interrupted Non-Absorbable Sutures in Arterial Anastomosis

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ABSTRACT

Suturing has been the traditional method of choice for anastomoses of arteries and repair of defects since it was introduced early in the 20th century. Although convenient and well established, the need for a faster method of closure became evident. The introduction of the vessel closure system (VCS) using clips in 1983 helped achieve this goal, for it was proven to be a fast, easily applicable, economical method of vascular closure particularly in complex and multiple vascular injuries and in areas that are difficult to approach mechanically. Although it will probably never replace traditional suturing, it is a much welcomed tool that may aid the surgeon in difficult vascular repairs. In this study performed on animals, 10 goats had their aortas anastomosed: five traditionally by sutures and the rest by the VCS method. The animals were sacrificed and the segments were examined. Both groups had healed adequately without complications. The striking difference was the speed and ease of vascular closure using the VCS system versus traditional suturing.

Keywords: vascular repair – vascular clips – VCS system.

INTRODUCTION

Although the suturing technique was established as a method for vascular anastomosis in the beginning of the 20th century, the search for a simpler and more rapid method continued along other lines. In 1955, Samuels used V-shaped stainless steel clips to close longitudinal arteriotomy wounds and to perform anastomosis of the aorta in dogs. Although the clip application was more rapid and adhered to the requirement of a good vascular anastomosis, it never gained widespread use because of its high failure rate and complexity of use. In the 1980s, Kirsch and associates developed a new non-penetrating, arcuate-legged titanium vascular-closure clip, and subsequently used them in experimental studies to perform different types of microvascular anastomosis. Approval to market the device for vascular anastomosis and reconstruction was granted by the American Food and Drug Administration (FDA) in December 1993, and the device was designated VCS (Vessel Closure System) clip applier system by the United States Surgical Corporation (USSC, Norwalk, Connecticut). Recently published experimental studies suggest their applicability also in large vessels.

The purpose of this study was to compare the vascular-closing staple clips to the traditional interrupted sutures in performing arterial end-to-end anastomosis with special reference to the healing characteristics of the repaired vessels.

MATERIAL & METHODS

The study was conducted on 10 goats to investigate end-to-end anastomosis of the two free ends of the abdominal aorta, created experimentally. The vascular clip applier known as VCS (Tyco Healthcare-United States Surgical, Norwalk, CT) was used. Each applier has a cartilage with several titanium clips that are applied in a single-step maneuver. The next clip can be automatically mounted after each application. The end of the applier can be rotated to facilitate clip application.

Four different sizes of the clips are available, depending on the diameter of the vessel. In the current study medium sized VCS clips were used. Before its closure, both ends of the clip are 1.4mm apart, with a total clip length of 2.3mm. The cartilage contains 35 clips (Figure 1).
Animals were randomly allocated to any of the two groups. Following the induction of general anaesthesia by means of an endotracheal tube, the animal underwent a midline incision to expose the abdominal aorta. Before occlusion of the aorta 100 IU/kg Heparin were administered intravenously. Occluding clamps were then applied to the lower abdominal aorta. The clamped vessel was divided at a 45 degree angle midway between the two clamps. The lumen was irrigated to remove residual blood clots. In 5 animals, the anastomoses were performed using interrupted 6/0 polypropylene sutures. First, two fixation (anchoring) sutures were placed on the edges of the vessel 180 degrees apart in the circumference of the vascular stump (Figure 2). This was followed by serial interrupted sutures placed in the gap between the two fixating sutures (Figure 3).

Clip anastomosis was applied in the remaining 5 animals. This was preceded by placing three temporary fixating sutures 120 degrees apart in the circumference of the vascular stump to be connected. This was followed by insertion of serial medium sized clips into the vascular wall, with both ends of the endothelium brought into contact by the help of a pair of tweezers for proper adaptation and eversion (Figure 4). No anticoagulation was used postoperatively following any procedure of the series.

The time from cross clamping to the completion of the anastomosis was recorded in all animals; this included the time that was taken for further haemostasis if needed. The abdomen was closed in a single layer with 0 polypropylene sutures and the animal was extubated. As previously stated; no anticoagulation was administered postoperatively. The animals were allowed to survive for 30-42 (mean 34) days to
observe cellular proliferation rates. At the time of sacrifice, each animal was re-anesthetized and the abdomen exposed, patency of the aorta was confirmed. The anastomosed segment was then harvested, and the animal was euthanized, while still under anesthesia, using saturated potassium chloride solution. The harvested segment was then fixed overnight in 10% Formalin, and the sutures and clips were removed by microdissection. For histological examination, multiple sections of the specimens were taken and reviewed by a pathologist. The quality of healing at the anastomotic site was assessed, and wall thickness was measured.

RESULTS

The anastomosis by means of the VCS-Clip, as well as by sutures, could be performed by a single surgeon without any assistance. Anastomosis by clipping was both faster and easier and took less time to perform (clips: 12.6±3.1 min; suture: 21.9±5.5 min p<0.001) (Table 1). When clipping, an average of 16-18 clips were placed (mean 17.00±2.18 clips) in the 5 animals of the VCS group. In the suture group, where interrupted polypropylene sutures were used, 10-13 stitches were placed. No statistically significant differences were found between the number of clips or stitches needed in the suturing technique.

Table 1: Mean average time for anastomoses with vascular closure staple clips and interrupted polypropylene sutures

<table>
<thead>
<tr>
<th></th>
<th>Vascular closure staple clips</th>
<th>suture</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Reconstruction time (min)</td>
<td>12.6±3.1</td>
<td>21.9±5.5</td>
<td>&lt;0.001</td>
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</tbody>
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At the time of re-operation, all vessels were patent on clinical examination. By histological examination, no clip was shown to have come in contact with the intra-luminal blood flow by penetration of the intima. All anastomoses had healed satisfactorily, with minimal reactive changes in the form of foreign body-reaction and scattered lymphocytes. There were no significant differences in intimal or total thickness of the vessels anastomosed with clips or sutures. (Table 2).

Table 2: Mean intimal and total thickness of the vessels at arterial end-to-end anastomoses performed with vascular closure staple clips and interrupted polypropylene sutures

<table>
<thead>
<tr>
<th></th>
<th>Vascular closure staple clips</th>
<th>Suture</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intimal thickness (µm)</td>
<td>13.4</td>
<td>13.6</td>
<td>0.95</td>
</tr>
<tr>
<td>Total thickness (µm)</td>
<td>57.5</td>
<td>50.7</td>
<td>0.14</td>
</tr>
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</table>

DISCUSSION

The Vascular closure staple clip system (VCS) has emerged as a challenger to the conventional suture in vessel anastomoses techniques. In the review of the experiments with small arteries and veins, Kirsch et al. have shown that the mechanical properties of the anastomoses reconstructed with the VCS-clips are equivalent or superior to those following micro-suturing. In this study, arterial end-to-end anastomoses performed with vascular-closure staple clips resulted in wound healing as good as closure with interrupted polypropylene sutures, when assessed for vessels patency, leakage at closure line, intimal reaction and vessel healing. Similar results were also reported by Pikoulis & co-workers in their study on arterial reconstruction.

There was a significant difference in the speed of clip application when compared with
the traditional interrupted suture anastomoses (Table 1). Although a continuous suture is considerably faster than the interrupted sutures(7), the rationale for using interrupted sutures was adopted to exclude the effect of the suturing type, since the VCS clips are interrupted, to allow proper assessment of the healing characteristics of both methods. Several authors have reported a decrease in time needed for performing clip anastomoses supporting the results of this study(8,9,11,12). Deb et al.(13) and Zeebregts et al.(14) however, could not find any statistically significant difference between these variables.

Other authors have focused on either cross-clamping time or time of ischemia, finding differences between the time needed for performing the anastomosis with either clips or suture. Zeebregts et al.(15) reported a decrease in cross clamping times in anastomosis performed both in the carotid artery and in the aorta with clips than with sutures. However, these differences reached statistical significance in case of anastomoses performed in the carotids. Other reports focus only on the clip usage and therefore did not make any comparison with the suturing technique, limiting their data to description of the surgical time. Samuels(16) needed 5-12 minutes for performing a vascular anastomosis in a canine aorta. Shibata et al.(17) reported the use of VCS clips in patients with arteriosclerotic occlusive arterial disease, performing 18 clip anastomoses on which they spent a mean time of 10 minutes.

The much faster vascular closure staple clips method of closing vascular defects created many potential applications: They could be used for quick and safe repair of traumatic vascular injuries, especially in patients with multiple vascular injuries and those critically injured in which operative time can adversely affect their outcome. Another advantage is their applicability to confined places making them capable of accessing blood vessels that are relatively inaccessible or in case of inadvertent incisions. Shorter clamping time could avert the complications caused by prolonged end-organ ischemia. The effortless use of the clips could also be of advantage in operations that require multiple anastomoses, such as in renal or liver transplantation, and also in such operations that are done under limited anesthesia as arteriovenous fistulas. The impact of this method in carotid surgery is the focus of many studies.(9) The main setbacks of the use of vascular clips could be in their poor ability to close injuries or perform anastomosis in heavily diseased arteriosclerotic vessels(7). Another disadvantage is the need to place a significant amount of staples in large repairs or circumferential anastomoses that would require some increased technical manipulations, which could limit the use of clips in the repair of large defects.

REFERENCES

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