Mechanical vascular division in lung resection

Hisao Asamura*, Kenji Suzuki, Haruhiko Kondo, Ryosuke Tsuchiya

Division of Thoracic Surgery, National Cancer Center Hospital, 1-1 Tsukiji 5-chome, Chuo-ku, Tokyo 104-0045, Japan

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Abstract

Background: There is little information available regarding the relative advantage of stapling over ligation for major pulmonary vessels in lung resection. The thin and fragile structure of pulmonary vascular walls for their large luminal size might have made surgeons reluctant to use staplers. This study was intended to demonstrate the feasibility of pulmonary vascular division by staplers.

Methods: A total of 842 mechanical vascular divisions were performed for pulmonary artery (PA, n = 376), pulmonary vein (PV, n = 462), and azygos vein (AV, n = 4) in 603 consecutive pulmonary resections from 1997 to 1999 at the National Cancer Center Hospital, Tokyo. In this series, 99.8% of mechanical vascular divisions were performed with endostaplers (840 vessels), and only 0.2% was performed with conventional TA-type staplers (two vessels). The prevalence of problems related to mechanical stapling (stapling failure) and postoperative bleeding was studied retrospectively.

Results: There was only one incidence of stapling failure, in which the superior pulmonary vein was divided without the formation of staples (overall stapling failure rate, 0.1%). The bleeding was controlled by ligation of each divided stump during thoracotomy. There was no stapling failure for PAs or AVs. In no case did postoperative bleeding require rethoracotomy at the stapled line of the vessels.

Conclusions: Although temporary oozing was sometimes seen along the staple line, vascular division with endostaplers was highly reliable with only a 0.1% incidence of stapling failure for all kinds of vascular structures in the thorax. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Lung cancer; Surgery; Stapling; Pulmonary vessels

1. Introduction

The method used to achieve bronchial closure is one of the most important topics in the thoracic surgical community. There has been some controversy between sutured, hand-sewn closure and stapled closure in terms of bronchopleural fistula formation [1–8]. However, there is little information available regarding closure and division by staplers of intrathoracic vessels during pulmonary resection. In fact, the incidence of accidental failures in association with stapled division of pulmonary vessels has scarcely been examined. Since the walls of pulmonary vascular structures are more fragile than those in the systemic circulation, surgeons are likely to be concerned about the safe application of staplers for relatively large pulmonary vessels such as the main pulmonary arterial trunk.

In this retrospective review, we analyzed the type and incidence of stapling failures for pulmonary vessels in a total of 842 vascular divisions over the past three years at the National Cancer Center Hospital, Tokyo.
2.2. Vascular closure and division

In 603 patients who underwent pulmonary resection, a total of 842 mechanical vascular divisions were performed for the pulmonary artery, pulmonary vein, and azygos vein of various sizes in combination. A total of 376 PAs, 462 PVs, and four AVs were divided mechanically. Types of mechanically closed vessels according to size are shown in Tables 2 and 3 for PAs and PVs, respectively. For mechanical closure of vessels, endostaplers (Endopath Endocutter ETS-Flex 35, Endopath Endocutter ETS 35, Cincinnati, OH; ENDO GIA, ENDO GIA II Universal, U.S. Surgical, Norwalk, CT) were used in 840 closures (99.8%). Another type of conventional stapler (Premium TA, U.S. Surgical) was used in only two closures (0.2%). After a careful dissection of the vessels, they were circled with 0-silk string. A stapler was then gently applied and staples were fired without excessive pushing against the vessels (Fig. 1). For the division of main stem pulmonary arteries, the proximal portion was clamped beforehand and staplers were applied at its periphery to avoid accidentally injuring vascular wall. For all other vessels, proximal clamping was not applied. No additional stitches were applied to closed stumps.

2.3. Evaluation

The prevalence of closure failure and postoperative bleeding was calculated according to the operative mode and method of closure. ‘Vascular stapling failure’ was defined as massive bleeding that required additional stitches or ligation for hemostasis, and was predominantly due to the stapling itself at the staple line or at the vascular wall close to the staple line. Postoperative bleeding refers to bleeding after closure of the chest at the stapled vessels which required re-thoracotomy for hemostasis.

Table 1
Operative procedures with stapled division of at least one thoracic vessel

<table>
<thead>
<tr>
<th>Type of pulmonary resection</th>
<th>Right side</th>
<th>Left side</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonectomy</td>
<td>14</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>Bilobectomy</td>
<td>36</td>
<td>36</td>
<td>72</td>
</tr>
<tr>
<td>Lobectomy</td>
<td>332</td>
<td>191</td>
<td>523</td>
</tr>
<tr>
<td>Total</td>
<td>382</td>
<td>221</td>
<td>603</td>
</tr>
</tbody>
</table>

Table 2
Types of mechanically closed pulmonary arteries according to size

<table>
<thead>
<tr>
<th>Level of artery</th>
<th>Right</th>
<th>Left</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main trunk artery</td>
<td>12</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>Lobar artery</td>
<td>183</td>
<td>40</td>
<td>223</td>
</tr>
<tr>
<td>Combined segmental branches</td>
<td>24</td>
<td>50</td>
<td>74</td>
</tr>
<tr>
<td>Single segmental branch</td>
<td>16</td>
<td>21</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td>235</td>
<td>141</td>
<td>376</td>
</tr>
</tbody>
</table>

Table 3
Types of mechanically closed pulmonary veins according to size

<table>
<thead>
<tr>
<th>Level of vein</th>
<th>Right</th>
<th>Left</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior or inferior pulmonary vein</td>
<td>234</td>
<td>197</td>
<td>431</td>
</tr>
<tr>
<td>Combined segmental branches</td>
<td>20</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Single segmental branch</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>259</td>
<td>203</td>
<td>462</td>
</tr>
</tbody>
</table>

3. Results

Of the 842 mechanical vascular divisions, stapling failure, which required another ligation for hemostasis, occurred in only one (overall prevalence, 0.1%). Although oozing from the staple line of the vascular stump was occasionally seen, it was controlled only by temporary compression. The sole stapling failure occurred in the superior pulmonary vein during video-assisted right upper lobectomy. Despite misalignment of the cartridge during insertion of the stapler, the staples were fired. There was no infolding of the staples and only the knife ran, which caused bleeding.
4. Discussion

Mechanical closure of the bronchial stump with staplers is being recognized as a safe and effective alternative to hand-sewn closure. Our previous study on 533 bronchial closures also demonstrated a low incidence of bronchopleural fistula for stapled closure (1.2%) [9]. However, there is little information available regarding the division and closure of pulmonary vascular structures by staplers. A few anecdotal reports and some clinical experiences have attested to the security of metallic suture lines placed on pulmonary vessels.

One of the great concerns in the use of pulmonary vascular stapling is the fragility of pulmonary vascular walls compared to those of systemic vascular systems. Due to the much lower perfusion pressure of the pulmonary circuit, there are differences in the anatomic structures of both pulmonary arteries and veins [10]. The lumina of major pulmonary arteries are widely dilated compared to the wall thickness. Elastic lamellae are scarce in the arterial media. The pulmonary trunk is about 40–80% as thick as the aorta. These characteristic features might have made surgeons reluctant to use stapling devices on hilar vascular structures. However, the present study demonstrated that, despite these characteristics, stapling could be accomplished safely without serious tearing if used properly. In fact, due to the low pressure of the circuit, oozing at the points of penetration by staples can be easily controlled by simple compression.

Sugarbaker and Mentzer described an improved technique for hilar vascular division with reloadable TA-type staplers [11]. They change cartridges in position to fire the second one, and this is followed by division of the vessel by knife. They were concerned about the possibility of misfire and a so-called postage-stamp effect due to double stapling. In contrast to this technique, most of the closures in the present series were performed by endostaplers, which only require a single motion. Indeed, misfire at large vascular structures such as the main trunk of the pulmonary artery might cause serious bleeding. For these reasons, we clamped the vessels at the proximal portion and applied the stapler to the distal side. However, considering the extremely low incidence of misfire and serious bleeding, we can rely on endostaplers for vascular division, and double stapling of both sides of the vessels with a TA-type stapler is not always necessary.

In some circumstances, a straight stapler is not applicable, since the root of the vessel is fixed to the pulmonary hilum. For this reason, we prefer to use articulated endostaplers such as FLEX or ENDO GIA Universal. The results of the present series clearly demonstrated the safety of stapled-closure of pulmonary vessels, and that the application of present endostaplers to relatively fragile pulmonary vessels is highly reliable.

Vascular division by stapler offers several possible advantages over individual ligation. First, the length of dissection required for safe division is greatly reduced if staplers are used. In the case of ligation, we must dissect the vascular wall away from the surrounding tissues to achieve a sufficient length so that the strings around the wall at both divided ends do not slip down at the time of division with scissors. In contrast, for stapled divisions, the length of dissection needs to merely be sufficient to apply an anvil safely. This might be a great advantage in cases in which a tumor or metastasized lymph node is located very close to the vascular structures, or with extensive adhesion. Furthermore, the time required for each dividing procedure is also considerably reduced. Slipping of the vascular stump is also expected to be less likely with staplers than with ligation, since staples pierce and approximate both sides of the vascular wall. In contrast, strings for ligation are only placed around the wall without piercing the wall structure. Even for ligation sutures, the wall is pierced only at one point, and thus there is a possibility of slipping.

On the other hand, several points should be considered for the safe use of endostaplers. Although the stapler can allow a shorter dissection than ligation, with a large vessel or when calcified nodes are attached to the vascular wall, a good length of dissection is desirable. Especially for large vessels such as the main trunk of the PA, a misfire might result in a potentially fatal injury, that would require a difficult surgical repair and the loss of a large amount of blood. Therefore, the proximal side of the vessel should be clamped before staple-closure. Third, as seen in our series, misalignment of the cartridge and anvil may cause a misfire. In particular, a slight misalignment might occur during repeated insertion and removal from surgical ports.

In conclusion, pulmonary vascular structures, both PAs and PVs, can be closed and divided safely using the present endostaplers with a very low incidence of stapling failure such as wall injury and subsequent bleeding. These staplers may be improved as follows: (1) a smaller anvil and cartridge portion of the stapler, so that it can be used on much smaller vessels and to minimize dissection of the vascular wall from surrounding tissues; (2) more sophisticated articulation of the anvil–cartridge complex, so that staplers can be applied more easily; (3) a lower cost, especially of staple cartridges.

Acknowledgements

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References

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