Slip Knot Bronchial Ligation Method for Thoracoscopic Lung Segmentectomy

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We report a novel monofilament slip knot technique for bronchial ligation and for visualization of the anatomic plane during lung segmentectomy. After threading the bronchus, a slip knot is made outside the thorax. During lung ventilation, one end of the string is pulled, and the knot slips to reach the bronchus without a knot-pusher. Bronchial ligation is then performed to block the outflow of segmental air while the segment remains expanded, whereas the other segments become collapsed. This technique allows identification of the anatomic intersegmental plane, facilitating thoracoscopic anatomic lung segmentectomy.


In recent years, anatomic segmentectomy is increasingly being considered for resection of small, stage IA non-small cell lung cancers. However, reports describing minimally invasive segmentectomy techniques are few, and the techniques themselves are not refined. The key to performing anatomic thoracoscopic segmentectomy is accurate delineation of the inflation-deflation line and comprehension of the segmental arteries and intersegmental veins, which are reliable landmarks of the intersegmental plane [1, 2]. We describe our method for creating an inflation-deflation line for lung segmentectomy that could especially be useful in thoracoscopic procedures for lung segmentectomy.

Technique
Under unilateral differential ventilation, thoracoscopic anatomic segmentectomy of the lung is initiated by dividing the arteries using 3-dimensional computed tomography simulation to isolate the bronchus [2, 3]. After threading the bronchus with a 3-0 or 4-0 polypropylene monofilament suture, a modified Roeder knot is made outside the thorax (Fig. 1). The knot is slightly tightened, and the long end of the suture monofilament is pulled so that the knot easily slips down to reach the operative field without requiring a knot-pusher (http://www.youtube.com/watch?v=UEpQNdrEkfA). Both lungs are ventilated, and the knot is fully pulled to ligate the bronchus with full expansion of the lung. The ipsilateral lung is again collapsed, and the affected segment remains inflated while the other segments appear to be collapsed. The bronchus is either carefully divided with a stapler or double ligated and cut if the bronchial diameter is small. The demarcation lines between the inflated and deflated lung parenchyma become visible [1]. The surgeon then dissects the parenchyma along the inflation-deflation line or the intersegmental vein, using either electrocauterization or tissue sealer (Figs 2, 3).

Between 2004 and 2012, 139 patients underwent thoracoscopic anatomic segmentectomy. The mean operative time was 210 minutes (range, 75 to 425 minutes) for 88

Fig 1. Modified Roeder knot customized for bronchial ligation. To make the knot, create a half hitch and hook this throw using the third finger of the left hand. Wrap the end three or four times around the limbs of the loop. Bring the end back, hold this end between the thumb and third finger, and then pass through the loop that was made with the hitch.
procedures before the introduction of this method, and it was shortened to 164 minutes (range, 71 to 283 minutes) for 51 procedures after the routine application of this new method.

**Comment**

In recent years, the diagnosis of peripheral, small, stage IA non-small cell lung cancers such as ground-glass opacity nodules has been increasing because of the use of computed tomography [4]. Therefore, limited resection and minimally invasive surgical techniques are in great demand. Anatomic segmentectomy is increasingly being considered for resection of such lesions, although techniques involving segmentectomy through minimally invasive approaches are not yet refined. Anatomic thoracoscopic segmentectomy depends on accurate delineation of the inflation-deflation line and comprehension of intersegmental veins, which are reliable landmarks of the intersegmental plane [1–3, 5].

We have previously reported the importance of 3-dimensional simulation using multidetector computed tomography for interpretation of individual segmental anatomy [2, 5]. The segmental vein is usually located between the segments, although considerable variations can be seen. Therefore, visualization of the inflation-deflation line is the standard approach for understanding the precise segmental plane. In conventional methods, occlusion of the segmental bronchus in an airless lobe is followed by expansion of the lung to outline the inflation-deflation line, and the affected segment is kept collapsed. However, this technique is associated with the problem of collateral ventilation through Kohn’s pores, which may fill the affected segment with unneeded air. Selective jet ventilation into the affected segmental bronchus has been described to demarcate the inflation-deflation line and
has the additional merit of allowing precise assessment of the surgical margin [1]. We chose the method involving expansion of the affected segment. However, jet ventilation is not available in many hospitals, and only experienced anesthesiologists or surgeons can identify the bronchus appropriately. Furthermore, we could not effectively insert the bronchoscope into the smaller bronchi during resection at the subsegmental (third order) bronchial branches [6]. Therefore, we attempted to block the bronchus by ligation with expansion of the affected segment, especially in segmentectomy of smaller bronchial calibers. We previously used the knot-sending method for bronchial ligation, in which a knot was made outside the thorax and sent with a knot-pusher and was tightened. However, this method cannot be performed quickly after inflation; therefore, the affected segment will be partly deflated, which may finally obscure the inflation-deflation line.

Some abdominal or arthroscopic surgeons commonly use the pretied slip knot technique [7, 8]. We found that the monofilament slip knot, customized from the previously reported modified Roeder knot, was useful because it enabled the surgeon to ligate the bronchus during ventilation of the lung and consequently identify the inflation-deflation line with collapse of the other segments. In conclusion, the monofilament slip knot technique enables precise dissection of the intersegmental plane during thoracoscopic anatomic lung segmentectomy.

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References