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Feasibility and Safety of a New Chest Drain Wound Closure Method with Knotless Sutures

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Background: A method of wound closure using knotless suture material in the chest tube site has been introduced at our center, and is now widely used as the primary method of closing chest tube wounds in video-assisted thoracic surgery (VATS) because it provides cosmetic benefits and causes less pain. **Methods:** We included 109 patients who underwent VATS pulmonary resection at Samsung Medical Center from October 1 to October 31, 2016. Eighty-five patients underwent VATS pulmonary resection with chest drain wound closure utilizing knotless suture material, and 24 patients underwent VATS pulmonary resection with chest drain wound closure by the conventional method. Complications related to the chest drain wound were compared between the 2 groups. **Results:** There were 2 cases of pneumothorax after chest tube removal in both groups (8.3% in the conventional group, 2.3% in the knotless suture group; p=0.172) and there was 1 case of wound discharge due to wound dehiscence in the knotless suture group (0% in the conventional group, 1.2% in the knotless suture group; p=0.453). There was no reported case of chest tube dislodgement in either group. The complication rates were non-significantly different between the 2 groups. **Conclusion:** The results for the complication rates of this new chest drain wound closure method suggest that this method is not inferior to the conventional method. Chest drain wound closure using knotless suture material is feasible based on the short-term results of the complication rate.

Key words: 1. Chest tubes
2. Sutures
3. Video-assisted thoracic surgery
4. Complication
5. Lung

Introduction

The insertion of a chest drain is a routine procedure in the treatment of many thoracic diseases, and especially for general thoracic surgery. The conventional method usually utilizes an anchoring suture and a purse-string suture for wound closure when the chest tube is removed. Other methods use a stapler or petroleum gauze to seal the chest tube wound during removal. These methods, although reliable, may have potential drawbacks, as pain is triggered during clipping with a stapler [1]. In addition to the possibility of an unsightly scar, air or contaminants may be introduced into the pleural space

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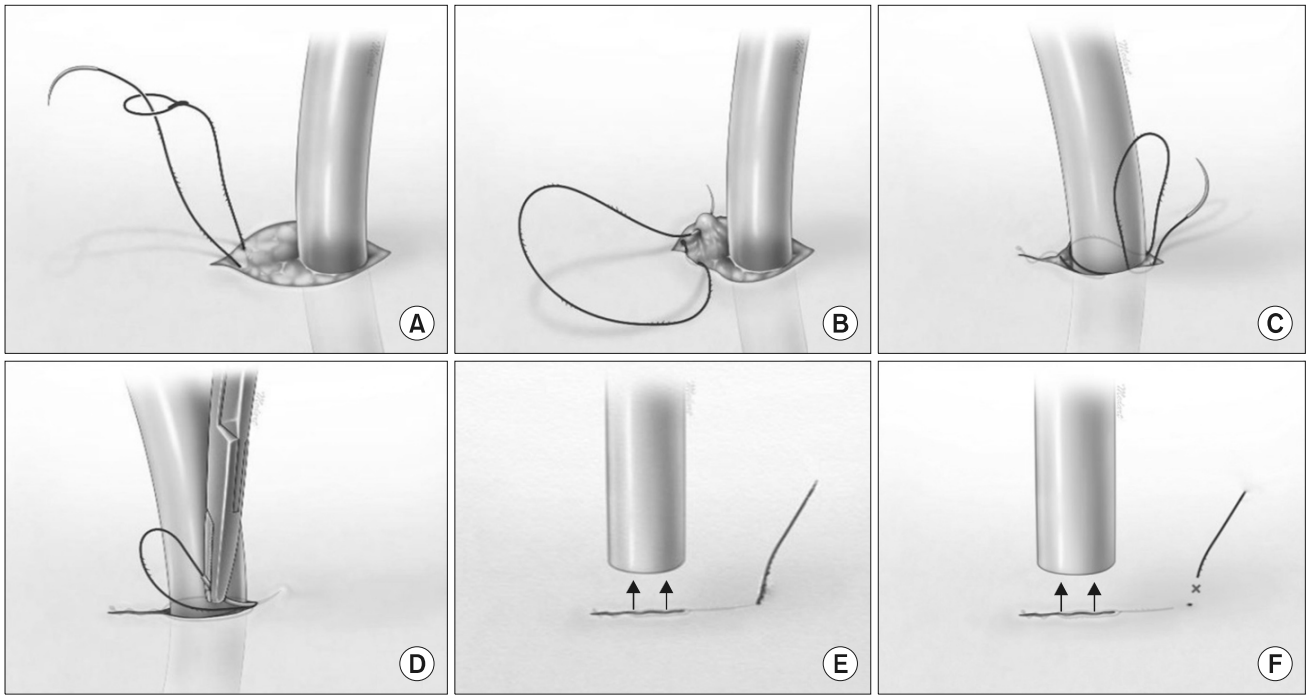

Fig. 1. Technique of chest drain wound closure and chest tube removal. From Kim et al. Ann Thorac Surg 2017;103:e93-5 [2]. (A) After suturing the muscle layer, closure of wound using knotless sutures begins at the one end of an incision. Instead of tying the knot, the tip of the needle enters through the fixation loop and is tightened. (B) The needle is placed horizontally through the subcutaneous tissue by passing through the opposite sides of the wound exactly same as in the continuous subcutaneous suture technique. (C) The suture continues around the chest tube until the needle reaches the other end of the incision. (D) At the other end of the incision, the tip of the needle passes under the skin and comes out through the skin about 1 cm away from the edge of the incision. (E) After the chest tube is removed, the secured thread is pulled forward to tighten the suture. Then the wound is sealed as with a zipper. (F) Leftover thread is cut off and nothing is left over at the scar of the chest tube site.

during removal of the chest tube. A method of wound closure using knotless suture material in the chest tube site has been introduced at our center [2], and is now widely used as the primary method of closing chest tube wounds in video-assisted thoracic surgery (VATS). The knotless suture method utilizes a unidirectional anchoring barb, which eliminates the need to tie knots and does not slip back [2]. The aim of our study was to evaluate the surgical outcomes and feasibility of this new chest drain wound closure method.

Methods

1) Patient selection

We included patients who underwent VATS pulmonary resection at Samsung Medical Center (SMC) from October 1 to October 31, 2016. Patients who underwent esophageal resection, mediastinal resection, or open pulmonary resection were excluded from this study. A total of 111 patients underwent VATS pulmonary resection at SMC during this period. Among the 111 patients, 1 patient was excluded from the analysis of postoperative complications due to death in the early postoperative period and another patient was also excluded due to prolonged hospitalization for other complications. Eight-five patients underwent VATS pulmonary resection with chest drain wound closure utilizing knotless suture material (Stratafix [Ethicon, Somerville, NJ, USA] or V-loc [Covidien, Minneapolis, MN, USA]) and 24 patients underwent VATS pulmonary resection with chest drain wound closure by the conventional method. We assumed that the surgical procedure would not influence the outcome of chest tube wound-related complications. Lung cancer was the primary disease for which pulmonary resection was performed, in addition to a few cases for benign lung diseases such as non-tuberculous mycobacteria (NTM). The chest drain wound closure method was chosen based on

Table 1. Baseline patient characteristics

Characteristic	Conventional (n=24)	Knotless suture (n=85)	p-value
Age (yr)	58.9	57.9	0.778
Gender (male:female)	13:11	38:47	0.417
Diabetes mellitus	2 (8.1)	12 (13.8)	0.459
Hypertension	9 (36.0)	28 (33.3)	0.680
Chronic obstructive pulmonary disease	0	4 (4.6)	0.273
Hepatitis	1 (6.3)	2 (2.3)	0.635
Chronic kidney disease	0	1 (1.1)	0.588
Body mass index (kg/m^2)	23.4	23.8	0.534

Values are presented as number (%), unless otherwise stated.

Table 2. Surgical procedures and average time of surgical procedures

Variable	Conventional (n=24)	Knotless suture (n=85)	p-value
Video-assisted thoracic surgery			
Wedge resection	1 (4.2)	31 (36.5)	-
Segmentectomy	4 (16.7)	12 (14.1)	-
Lobectomy/sleeve lobectomy/bilobectomy	14 (58.3)	32 (37.6)	-
Pleural biopsy	5 (20.8)	9 (10.6)	-
Procedure time			
Average operation time (min)	169.3	153.6	0.219
Average suture time (min)	22.0	20.3	0.340

Values are presented as number (%), unless otherwise stated.

the surgeon's personal preference.

2) Surgical method

(1) Knotless suture method: As each operation was completed, the chest drain was inserted and an anchoring suture was placed with either silk or nylon. After the muscle layer was sutured, the subcutaneous layer was sutured using unidirectional absorbable sutures, either Stratafix (Ethicon, Somerville, NJ, USA) or V-loc (Covidien, Minneapolis, MN, USA). Closure of the chest drain began at the end of an incision; instead of tying the knots, the tip of the needle entered through the fixation loop and was tightened. The needle was then placed horizontally through the subcutaneous layer by passing through the opposite sides of the wound in exactly the same way as is done in the continuous subcutaneous suture technique. The suture continued around the chest tube until the needle reached the other end of the incision. The tip of the needle passed under the skin and came out through the skin about 1 cm from the edge of the incision. The needle was then cut off and the rest of the thread was secured to the skin with an adhesive [2]. When the chest tube was being removed, the anchoring suture was cut off, and then the chest tube was withdrawn while the adjacent tissue was held tightly to prevent pneumothorax. The secured thread was then pulled forward to tighten the suture. Fig. 1 illustrates the knotless suture method [2].

(2) Conventional method: The chest drain was inserted and an anchoring suture was placed with either silk or nylon. A purse-string suture was placed around the chest tube, whirled around, and fixed with the chest tube. When the chest tube was to be removed, the anchoring suture was cut off and the purse string suture was tied as the chest tube was withdrawn.

3) Outcomes

Complications related to the chest drain wound were compared between the conventional group and the knotless suture group. The following complication-related factors were analyzed: wound dehiscence, pneumothorax after chest tube removal, dislodgement of the chest tube, and dressing required at the outpatient clinic. The complication rate was measured by reviewing all charts from each patient's period of hospitalization and outpatient clinic records.

The research protocol was approved by the institutional review board of SMC (IRB approval no., 201711076). And the written informed consent was waived

Results

The characteristics of the patients in the 2 groups are shown in Table 1. The gender ratio, age, other comorbidities, and body mass index did not show statistically significant differences. The surgical procedures in the 2 groups are shown in Table 2. The proportion of lobectomy was greater in the conventional group than in the knotless suture group (58.3% versus 37.6%). There was no statistically significant difference in the average operation time (169.3 minutes versus 153.6 minutes, p=0.219) or

Table 3. Duration of hospitalization and duration of chest tube insertion

Variable	Conventional	Knotless suture	p-value
Average hospitalization time (day)	7.8	7	0.176
Average chest tube duration (day)	4.3	3.7	0.125
Average total chest tube output (mL)	782.2	508.5	0.036

Table 4. Chest drain related complications

Variable	Conventional (n=24)	Knotless suture (n=85)	p-value
Pneumothorax after chest tube removal	2 (8.3)	2 (2.3)	0.172
Wound dehiscence	0	1 (1.2)	0.453
Dislodgement of chest tube	0	0	Not applicable
Dressing required at outpatient department	20 (83)	31 (36.5)	<0.05

Values are presented as number (%), unless otherwise stated.

suture time (22.0 minutes versus 20.3 minutes, p=0.340) between the conventional group and knotless suture group. The patients' postoperative course is described in Table 3. The average hospitalization time was 7.8 days for the conventional group and 7 days for the knotless suture group (p=0.176). The average duration of chest tube insertion was 4.3 days for the conventional group and 3.7 days for the knotless suture group (p=0.125). The only statistically significant difference between these 2 groups was the amount of average total chest tube drainage, which was 782.2 mL for the conventional group and 508.5 mL for the knotless suture group (p=0.036). We believe that the greater average amount of total chest tube drainage in the conventional group was due to the fact that the distribution of surgical procedures was different between the 2 groups. Complications related to chest wound closure complications are presented in Table 4. There were 2 cases of pneumothorax after chest tube removal in both groups (8.3% for the conventional group versus 2.3% for the knotless suture group, p=0.172), and chest tube re-insertion was performed in all 4 patients. There was 1 case of wound discharge due to wound dehiscence in the knotless suture group (0% for the conventional group versus 1.2% for the knotless suture group, p=0.453) and re-suturing was performed for that patient at the outpatient clinic. We believe that this case was due to a technical error, wherein the thread was not pulled well enough to tighten the chest drain wound. No case of chest tube dislodgement was reported in either group. The complication rates did not show statistically significant differences between the 2 groups.

Discussion

Only a few studies have been published regarding chest tube wound closure methods. The conventional method of closing a chest tube is to use an anchoring suture to fixate the chest tube while a purse-string suture is used to close the wound after the removal of the chest tube. This method secures the chest tube in position while preventing air or pleural fluid from entering the pleural space during the removal process with the closing purse-string suture. The disadvantage of the conventional method is the unsightly scar that is left after the stitch is removed. Moreover, dressing for the chest tube removal site is required at home, after the patient is discharged from the hospital, and the remaining suture material should be removed at a subsequent outpatient visit. This causes substantial inconvenience for the patient. Several recent reports have described new methods of closing chest tube wounds. Yokoyama et al. [3] reported a new technique for chest drain removal using a 2-layer method with triclosan-coated sutures. The method consists of a 2-layer suture in the muscular and epidermal layers with the use of 00-gauge triclosan-coated sutures. Yokoyama et al. [3] claimed that this method had advantages, including no need for stitch removal at follow-up, good wound healing, and fine, cosmetically pleasing scars without an increased chance of infection. They followed up 168 patients treated with this method for 24 months and reported no complications such as infection, fluid leakage, or opening of the surgical wound. Inzirillo et al. [4] reported the "Roman sandal" modified method for securing the chest drain, which features a single suture acting as "tube fixing" and "wound closure" by an alpha shape made up of cross-wires inserted in to

and around the wound. The authors suggested that this method was quicker to perform during application and removal of the drain and had excellent cosmetic results.

We obtained better surgical outcomes for chest tube wound closure by making an appropriate skin wound approximation using a knotless absorbable suture material, resulting in satisfactory cosmetic outcomes and safety. Knotless suture materials have recently been applied in many surgical fields. Virdarsson et al. [5] reported that during gastric bypass, knotless suture materials were used to close the opening in the gastrojejunostomy and shortened the operative time without increasing the risk of complications. Several reports have described the use of a knotless suture material during vesicourethral anastomosis during robot-assisted radical prostatectomy [6,7]. In cardiac surgery, the use of a knotless suture material was found to be efficacious in mitral valve surgery, obstetric and gynecologic surgery, and general surgery. Our new method using a knotless suture material is easier and less painful than the conventional method in terms of insertion of the chest drain and removal of the chest tube. Its cosmetic benefits are another strong point of this method. The patients were pleased with the fact that dressing was not required after chest tube removal, and this was also convenient for the surgeons, as there was no need for stich removal and dressing at the outpatient clinic. In this study, we examined the rate of chest tube-related complications in 2 separate groups: patients who underwent chest drain wound closure with knotless suture material and those who underwent chest drain wound closure by the conventional method. A total of 109 patients (24 in the conventional group versus 85 in the knotless suture group) were examined for wound complications, accidental chest tube withdrawal, and pneumothorax after chest tube removal. Pneumothorax after chest tube removal could be due to a technical error. However, in a retrospective analysis of our practice of covering the wound with petroleum gauze after chest tube removal without a purse-string suture, the incidence of pneumothorax and wound dehiscence was higher. Therefore, we wanted to ensure that this new method would not increase the incidence of pneumothorax, wound dehiscence, and dislocation of the chest tube. The incidence of chest tube-related complications was statistically non-significant, and the only statistically significant difference was the incidence of dressing performed at the outpatient clinic. Chest drain wound closure with knotless suture material does not require a chest drain wound dressing once the chest tube is removed, which means that dressing at the outpatient clinic was not necessary. Our review of the medical charts of all patients treated at the outpatient clinic indicated that a small number of surgeons did apply a dressing at the outpatient clinic for patients in the knotless group, but we believe this to have been unnecessary.

Most of the operations were performed in patients with lung cancer or lung metastasis, and only few procedures were in patients with benign diseases such as NTM. We thought that chest drain wound-related complicates might be more prevalent in patients with inflammatory benign diseases, but due to the small number of such patients, we could not conduct a subgroup analysis in terms of benign versus malignant diseases. Although the knotless group had a greater proportion of wedge resection and a lower proportion of lobectomy, we assumed that the surgical procedures would not affect complications related to the chest drain wound. The average operation time, average suture time, average hospitalization stay, and average chest tube duration did not significantly differ between the groups. However, all those parameters tended to be longer for the conventional group, and the average amount of chest tube drainage was significantly greater in the conventional group. Although this did not translate into more chest drain wound-related complications, we do admit that these factors could have affected the outcomes. Further study is required with a larger patient pool and surgical procedure-adjusted groups to validate our assumption that the type of surgical procedure is unrelated to chest drain wound-related complications.

Our results suggest that chest drain wound closure using knotless suture material is as safe and feasible as the conventional method for securing the chest tube in place and that it allows the wound closure to be tightened well enough after chest tube removal, as indicated by the fact that wound-related complications did not appear to increase with the new method. The results regarding the complication rates of this new chest drain wound closure method suggest that this method is not inferior to the conven-

tional method. Most chest tube wound closures for general thoracic surgery at our center are now performed using this new method. The major limitation of this method, as explained in a previous article [2], is the fact that the incision must be 10%–20% larger than in the conventional method in the beginning. This can be overcome by downsizing the chest tube, and the problem resolves as one becomes more experienced with the new method. Another problem is cost, as the knotless suture material does cost more than other suture materials. This problem should be approached in a cost-and-benefit framework, as we believe that this new method is worth the cost.

In summary, we found no differences in the surgical outcomes between the 2 groups. Our method of chest drain wound closure using knotless suture material is as safe and feasible as the conventional method for securing the chest tube in place and for wound closure after chest tube removal.

In conclusion, this new method of chest drain wound closure using knotless suture material was found to be feasible, based on short-term results regarding the complication rate. We showed that the clinical outcomes obtained with knotless suture material were not inferior to those obtained using the conventional chest tube wound closure method. Further study is required to obtain more concrete clinical evidence.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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