Comparative Evaluation of Scar Tissue from Chest Tube Wound Closure Using Knotless and Conventional Methods Using the Patient and Observer Scar Assessment Scale

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Abstract

Introduction. Chest tube placement is widely practiced; most medical doctors can do this safely. However, releasing the chest tube can be a painful and challenging experience for the patient. A novel method has been developed with a new suture material that does not need to be knotted. The Patient and Observer Scar Assessment Scale (POSAS) provides objective and subjective scar assessment. This study aimed to compare the scars associated with chest tube release between the conventional and knotless methods.

Methods. The study was a controlled trial in which patients were divided into two groups. The scar assessment was carried out by the researcher and the patient in the third month after the operation, using POSAS scores.

Results. The Mann-Whitney test showed significant differences between the methods in both patient and researcher assessments (p < 0.05). However, the correlation test between the total POSAS scores from the patient and researcher assessments showed a high linear relationship (r = 0.988; p < 0.001).

Conclusion. According to POSAS scores, scar tissue formation from the knotless method was more acceptable to patients than the conventional method. Therefore, this can be an alternative method for chest tube wound management.

Keywords: scar tissue, chest tube, Patient and Observer Scar Assessment Scale, knotless.

Introduction

Chest tube or chest drain placement is widely practiced, and most medical doctors can do this safely.1 Chest tube placement is a life-saving procedure to drain fluids, blood, or air from the pleural cavity.2,3 Chest tube complications are categorized into placement and release complications 4. The release of the chest tube can be painful and difficult for the patient. Studies have shown that patients undergoing chest tube release experience moderate to severe pain. Unightly scars also cause stress to the patient.4 Safe and aesthetic outcome of the chest tube scar has long interested surgeons.

Indications for chest tube installation are divided into absolute and relative indications. Absolute indications include pneumothorax, tension pneumothorax, pleural effusion, empyema, and hemothorax, while relative indications are postoperative thorax, chylothorax, and subcutis emphysema.5 To these procedures, the most common closure method is covering the wound with Vaseline-gauze and plaster. However, wound healing via granulation yields unfavorable results. Obtaining a favorable result requires a good approximation of the wound edges.6 Wound closure by suturing, stapling, or gluing follows the chest tube release has been recommended to achieve this. However, these conventional methods have various adverse effects.2 Pain on releasing the chest tube occurs while tightening the stitches. Therefore, researchers seek a new method to reduce pain and leave less scar tissue. Cho7 has developed a novel technique with a new suture material that does not need to be knotted. This material leaves no scar and reduces pain.5

With many patients complaining about scarring and pain from chest tube wound closure, an assessment instrument based on patient reports is important. These outcomes significantly affect the patient’s quality of life regardless of the physical characteristics of the scar tissue. The Patient and Observer Scar Assessment Scale (POSAS) provides objective and subjective scar assessment. Objective assessment is quantitative, requiring a tool to measure the characteristics of scar tissue, whereas subjective assessment is qualitative, assessing the scar tissue in the observer’s and patient’s opinions.8 We thus compared scar tissue and pain from chest tube wound closure using the knotless and conventional methods, using the POSAS. This will help clinicians in reducing complications in patients with chest tube wounds.

Method

This study used a controlled trial design, with patients divided into two groups: experimental and control. We proceeded with a controlled trial design. The subjects were divided into two groups: treated and control. The chest tube wound closure of the first group used the knotless suture, whereas the control group received wound closure using the conventional suture method. Otherwise, all patients received similar treatment according to the standard handling procedures for patients after chest tube installation. The doctors and patients assessed the scar the same day in the third month later at the R. D. Kandou Hospital, Manado, Indonesia. The number of samples was determined using a formula comparing two treatments in which the outcome was a numerical variable, and both groups received the same sample allocation. The outcome, i.e., the scar, was assessed using the POSAS score. Data were collected and analyzed using paired t-test or Wilcoxon rank sum test. Research scores from either patients or researchers or a combination of both on differences in scarring caused by Knotless and Conventional methods. Further, a multivariable analysis proceeded to analyze the correlation coefficient R2 between the two groups.

The study participants were those who underwent surgical procedures of chest tube insertion and removal, had no empyema, had no history of keloids, had no neoplasms in the mammmary area, had no history of using immunosuppressants, and signed a written consent to participate.

Chest tube insertion

The main instruments used were: barbed suture STRATAFIX™ Spiral PDS 2.0 taper for the treatment group and polypropylene 2.0 cutting for the control group. All chest tube placements were supervised by a senior resident physician trained following standard protocols and techniques. Third-generation cephalosporin antibiotics

Keywords: chest tube, observer scar assessment scale, knotless.
were administered intravenously before the procedure. The chest tube was removed after the chest removal criteria were met for a maximum of two weeks from insertion by a resident, one of whom was at least a senior resident.

**Scalp assessment**

The wound and scalp were assessed by the Thoracic and Cardiovascular Surgeon, Plastic Reconstructive and Aesthetic Surgeon, and a senior resident at the outpatient clinic in the third month.

**POSAS score**

The scar was assessed objectively and subjectively using the Patient and Observer Scar Assessment Scale (POSAS). Objective assessment is quantitative that requires a tool to measure scarring characteristics, while subjective assessment is qualitative, which relies on scarring assessment from observers and patient opinions. The POSAS score includes itching, pain, thickness, flexibility, color, and surface relief of scar tissue, and an observer's score that provides thickness, pigmentation, vascularity, flexibility, surface relief, and the surface area of the scar. The score was expressed as: 5–50 (observer doctor), 6–60 (patient), and 12–120 (total of both).

**Statistical analysis**

The descriptive analysis to determine the distribution of the research variables was univariate or bivariate. The univariate analysis used the Shapiro–Wilk normality test. In addition, differences in patient characteristics by treatment group (knotless method and conventional method) were tested using the t-test and Mann–Whitney U test for numerical variables and the chi-square test or Fisher's exact test for categorical variables. The comparison between the conventional and knotless sutures was conducted on the bivariate level with a two-group test according to the type of variable: the t-test or its non-parametric equivalent for the POSAS score and the chi-square test or Fisher's exact test for each POSAS score parameter. Regression modeling was conducted according to the type of POSAS outcome used. Linear regression analyzed the POSAS score of each assessment (observing doctor, patient, and total). The regression analysis result is presented as a regression parameter estimation value and 95% confidence interval, and p-value. R statistical software version 3.6.3 was the primary tool for data processing and statistical analysis. To find a stable estimates in the multivariate analyses, we generated a sufficiently large dataset (n = 1000) via vine copula models based on the marginal distributions and dependence structure identified on the original dataset. Vine copula modeling has been described elsewhere. In short, a copula is a multivariate cumulative distribution function used to model the dependence between random variables. Once the marginal distribution of each variable and the bivariate rank correlation between each pair of variables are determined, one may create synthetic data using the copula. The term "vine" refers to the graphical similarity of this copula approach to the vine branches. The Committee of Ethics R. D. Kandou Hospital approved this study No. 116/EC/KEPK-KANDOU/XI/2020.

**Results**

A total of 36 patients who underwent the chest tube insertion were enrolled in the study, with 18 receiving stitches after the cannula was removed with each conventional or knotless method. The average patient age was 37.6 years. All but four were male (89%). The basis for chest tube installation varied, with the most significant proportion (81%) of pneumothorax, hemothorax, or a combination of both. The affected lung area was evenly distributed in the right and left lobes. No significant differences existed in characteristics between subjects who received conventional sutures and those who received knotless sutures. Table 1 shows the characteristics of the subjects.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total (n = 36)</th>
<th>Conventional (n = 18)</th>
<th>Knotless (n = 18)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4 (11)</td>
<td>2 (11)</td>
<td>2 (11)</td>
<td>1.00</td>
</tr>
<tr>
<td>Male</td>
<td>32 (89)</td>
<td>16 (89)</td>
<td>16 (89)</td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>11 (31)</td>
<td>4 (22)</td>
<td>7 (39)</td>
<td>0.827</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>7 (19)</td>
<td>4 (22)</td>
<td>3 (17)</td>
<td></td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>11 (31)</td>
<td>6 (33)</td>
<td>5 (28)</td>
<td></td>
</tr>
<tr>
<td>Hydrothorax</td>
<td>7 (19)</td>
<td>4 (22)</td>
<td>3 (17)</td>
<td></td>
</tr>
<tr>
<td>Affected lung</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>18 (50)</td>
<td>8 (44)</td>
<td>10 (56)</td>
<td>0.739</td>
</tr>
<tr>
<td>Right</td>
<td>18 (50)</td>
<td>10 (56)</td>
<td>8 (44)</td>
<td></td>
</tr>
</tbody>
</table>

Note: SD, Standard deviation; Q1, Quartile I; Q3, Quartile III; *t-test or chi-square test.

In the first month's measurement, the highest median score on the patient form was for the stiffness and thickness items, and the lowest was for the pain item. Patients' scores tended to be higher than the scores given by the observers. The median on the forms completed by doctors was almost evenly distributed on all items, with a total median score of 17. The decreasing score for each item and the total was visible on the third day of the POSAS assessment. The lowest value on the patient-completed form was for the relief item, where the total median patient score was 19.0 (IQR 15.0–21.0). For observing doctors, the median score for each item was 2, and the total score dropped to 12 in the second assessment. The total assessment score for the third day was 30.0 and dropped around 10.5 points from the first month's results. The distribution of scores for each POSAS item by the observing doctors and patients is summarized in Table 2. Both the initial data and the copula modeling data support a robust linear relationship between the scores in the first and the third months (Figure 1), with the correlation value used for initial data t = 0.74 (p <0.001). Copula data estimation corrected this value to t = 0.53 (p <0.001). Although Figure 2 shows the impression of a positive relationship between the POSAS total values from observers and patients, a separate set of data points is visible, with one clustered at a relatively low total score and the other cluster of data points at a higher POSAS total score. This represents score clusters for both types of wound stitching. Figure 3 explains this visually. The relatively high POSAS scores were from patients with conventional wound sutures, and the relatively low scores were from patients with knotless wound sutures.
Table 2. POSAS score distribution

<table>
<thead>
<tr>
<th>Variable</th>
<th>POSAS score</th>
<th>First month Median (Q1–Q3)</th>
<th>Third month Median (Q1–Q3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>3.0 (3.0–3.0)</td>
<td>2.0 (2.0–2.0)</td>
<td></td>
</tr>
<tr>
<td>Itchiness</td>
<td>4.0 (3.0–4.0)</td>
<td>3.0 (2.0–3.0)</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>4.0 (3.0–5.0)</td>
<td>3.0 (2.0–4.0)</td>
<td></td>
</tr>
<tr>
<td>Stiffness</td>
<td>4.5 (4.0–5.0)</td>
<td>3.5 (3.0–4.0)</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>4.5 (4.0–5.0)</td>
<td>3.5 (3.0–4.0)</td>
<td></td>
</tr>
<tr>
<td>Relief</td>
<td>3.5 (3.0–4.0)</td>
<td>2.5 (2.0–3.0)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.0 (20.0–26.0)</td>
<td>19.0 (15.0–21.0)</td>
<td></td>
</tr>
<tr>
<td>Observer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vascularity</td>
<td>3.0 (2.0–3.2)</td>
<td>2.0 (1.0–2.0)</td>
<td></td>
</tr>
<tr>
<td>Pigmentation</td>
<td>3.0 (2.8–4.0)</td>
<td>2.0 (1.0–3.0)</td>
<td></td>
</tr>
<tr>
<td>Pliability</td>
<td>2.0 (2.0–3.0)</td>
<td>2.0 (1.0–2.0)</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>3.0 (2.0–4.0)</td>
<td>2.0 (1.0–2.2)</td>
<td></td>
</tr>
<tr>
<td>Relief</td>
<td>3.0 (2.0–3.0)</td>
<td>2.0 (1.0–2.0)</td>
<td></td>
</tr>
<tr>
<td>Surface area</td>
<td>3.0 (2.0–4.0)</td>
<td>2.0 (1.0–3.0)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17.0 (14.0–20.2)</td>
<td>12.0 (9.0–14.0)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Q1, Quartile I; Q3, Quartile III.

Table 3. Linear regression model of total POSAS score and suture type after chest tube removal.

<table>
<thead>
<tr>
<th>Variable</th>
<th>First month</th>
<th>Third month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knotless suturing</td>
<td>-12.17 (-13.64; -11.70)</td>
<td>-11.32 (-12.33; -10.31)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.07 (-0.12; -0.009)</td>
<td>-0.02</td>
</tr>
<tr>
<td>Female</td>
<td>-1.70 (-0.01; 3.41)</td>
<td>1.70 (-0.01; 3.41)</td>
</tr>
<tr>
<td>Left lung</td>
<td>-1.14 (-2.22; 0.06)</td>
<td>-1.14 (-2.22; 0.06)</td>
</tr>
</tbody>
</table>

Note: CI, confidence interval.

and the relatively low scores were from patients with knotless wound sutures. These conditions are seen better in the first-month assessment or on the third day after the chest tube removal. The knotless wound suture reporter with -12.17 points (p <0.001), and the conventional method in controlling scars is -11.32 points (p <0.001), especially after chest tube installation, supported by the regression analysis result (Table 3).
Discussion

Pain sensation using the Knotless method is less than in the conventional method, and scar formation in the Knotless method is more acceptable for patients than the Conventional method, which is assessed using POSAS scores. Studies on chest tube wound closure methods that reduce pain, complications, and scar tissue have long interested surgeons. Various techniques have been used to close these wounds. The conventional method uses horizontal mattress sutures leaving unsightly scar. A knotless method has been developed using a barbed suture that can reduce tissue pressure to shorten the inflammation phase.

Millions of people have scar tissue from burns, surgery, and trauma. Scars can have a significant impact on individuals. For example, scar tissue on the face can impact psychosocial function, and scar tissue from burns can affect physical function. The wound healing mechanism is important to learn concerning the formulation of scar tissue. The etiology and pathophysiology of hypertrophic scars and keloids are still unknown. Theories suggest that fibroproliferation is the cause of hypertrophic scars and keloids. The prolonged inflammation phase led to hypertrophic scars or keloids. The rising number of immune cells in keloids increases fibroblast activity and continues to form an extracellular matrix.

The knotless suture method is more accessible and less painful than the conventional method during the chest tube installation and removal. In addition, the patient is more satisfied as they require no wound dressing after the tube is removed, and this is comfortable for the operator because no requirement exists to remove the stitches and bandages. The knotless method is widely used in other medical fields for wound closure with more acceptable scars. In line with its pathophysiology, a barbed suture produces even pressure distribution along the wound by reducing stress on the skin, especially the wound edge, and preventing necrosis from tissue strangulation and microinfarction so that less inflammation occurs. This improves healing and produces more cosmetic scars and less pain from hypertrophic scars.

Based on previous study, this study aimed to prove that the knotless method can reduce pain complications and produce better scar tissue compared to the conventional method. The assessment instrument was POSAS, a scar tissue assessment based on patient and observer opinions because scar tissue is not assessed from its physical characteristics but also its impact on quality of life. Regardless of the assessment timing, patients receiving knotless sutures tended to report better scar tissue conditions (lower scores) than patients with conventional sutures. After controlling the variables of age and affected lung areas, the total POSAS score in the first-month assessment for patients with knotless sutures was on average lower by 12.17 points than the score reported by patients with conventional sutures. This number was relatively held on the third-month assessment for patients with knotless sutures was on average lower by 12.17 points than the score reported by patients with conventional sutures. This number was relatively held on the third-month assessment. Based on the research results, the tissue formation following chest tube removal with the knotless method was better than the conventional method. This study has some limitations. Further studies could involve microscopically assessing the quantity of scar tissue formation through histopathological examination.

Conclusions

Scar tissue formation with the knotless method was more acceptable for the patient than the conventional method, as assessed by POSAS scores. Therefore, this can be an alternative method for chest tube wound closure.

Disclosure

The authors declare no conflict of interest.

Acknowledgment

None.

Role of authors

Conceptualization ANT, MHO, MCO, CL, WS, CZT, FLFGL, Formal analysis ANT, MHO, MCO, CL, WS, CZT, FLFGL, Funding acquisition ANT, MHO, MCO, Investigation ANT, MHO, MCO, CL, WS, CZT, FLFGL, Methodology ANT, MHO, MCO, CL, WS, CZT, FLFGL, Project administration CZT, Resources ANT, MHO, MCO, CL, WS, CZT, FLFGL, Software ANT, MHO, MCO, CL, WS, CZT, FLFGL, Validation CZT, FLFGL, Writing original draft FLFGL, Writing review and editing ANT, MHO, MCO, CL, WS, CZT, FLFGL.

References


