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Research

The Development of the Arm Fixation Method to Prevent Ipsilateral Shoulder Pain in Patients Undergoing Lung Resection

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Keywords:
arm fixation method
ipsilateral shoulder pain
lung resection

A B S T R A C T

Purpose: The aim of the present study was to investigate the efficacy of a new upper limb fixation method—body pillow position for preventing postoperative ipsilateral shoulder pain (ISP) in patients undergoing lung resection.
Design: An experimental study design was used.
Methods: We conducted two comparisons (group A: the previous position using the arm fixation device; group B: the body pillow position) at random and examined an arm fixation method that is effective for ISP prophylaxis in patients undergoing surgery in the lateral decubitus position.
Findings: We approached 87 patients, two were excluded, and, thus, 85 were randomly assigned to group A ($n = 43$) or group B ($n = 42$). No significant differences were observed in the frequency of ISP between groups A and B (25.6% vs 26.2%). The intensity of ISP between both groups was analyzed by a repeated-measures analysis of variance and was shown to decrease over time in 22 patients ($P = .010$). The intensity of ISP on postoperative days 0 to 3 was slightly lower in group B than in group A ($P = .158$). Risk factors for ISP were the duration of surgery (odds ratio, 1.01; 95% confidence interval, 1.00 to 1.01) and pre-existing shoulder stiffness (odds ratio, 5.15; 95% confidence interval, 1.07 to 24.83).
Conclusions: There was no significance in the frequency of ISP between group A and group B. The intensity of ISP on postoperative days 0 to 3 was lower in group B than in group A, although there was no significant difference. It is important perspective for perioperative care providers to prevent ISP for early postoperative recovery and improvement of postoperative quality of life. These results suggested that we must consider a better position for preventing postoperative ISP in patients undergoing lung resection.

Postoperative pain management remains challenging, but has been improved by recent advances in surgical techniques, instruments, anesthetic procedures, and multimodal opioid-sparing medication management. Surgical procedures for lung resection have shifted from open thoracic surgery to video-assisted thoracoscopic surgery (VATS), robotic-assisted thoracoscopic surgery, and uniport VATS. Furthermore, the size of skin incisions is becoming increasingly smaller. Because most surgical procedures for lung cancer are performed in the decubitus position, patients often develop ipsilateral shoulder pain (ISP).[1,2] Although skin incision pain and its management have been examined in detail, limited information is currently available on ISP. Although postoperative pain management techniques have become more sophisticated and greatly contribute to the quality of life (QOL) of patients after surgery, the cause of postoperative ISP is unknown,[3] and prevention is important. It is an important perspective for perioperative care providers to prevent ISP for early postoperative recovery and improvement of postoperative QOL.

Background

Patients who have undergone thoracic surgery often develop ISP, and its incidence has ranged between 31% and 75% depending

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on the surgical procedure, surgical approach, patient positioning, and duration of surgery.[4-8] The intensity of ISP is scored between 3 and 9 on a 10-point numerical rating scale (NRS) or a visual analog scale and continues for 3 to 4 days after surgery.[5,7-9] In our previous study, we used the arm fixation method of Figure 1A in the decubitus position and found that 40.5% of patients who had undergone lung resection developed ISP. The maximum intensity of ISP was rated as 5.10 on a 10-point NRS, occurred on postoperative day 1, and then gradually decreased with time (days 1 to 3). Regarding changes over time in the intensity of shoulder pain, the highest rating of 5.1 was observed on day 1, and shoulder pain gradually decreased until day 4.[8] Although ISP has been attributed to referred pain from the phrenic nerve, muscle strain from positioning, or surgical damage to ligaments and muscles,[10-13] its etiology currently remains unclear. Bando et al[8] reported that the duration of surgery and pre-existing shoulder stiffness (excluding shoulder pain) significantly contributed to the development of ISP postoperatively. Bando et al also suggested that excessive stretching of muscles in the shoulder while patients were in the decubitus position resulted in ISP.

Double-blinded randomized studies have been conducted on anesthetic treatments for ISP using thoracic epidural anesthesia, suprascapular nerve block, and interscalene brachial plexus block[5]; however, few have investigated preventive positioning during surgery for ISP. Most studies on perioperative postures and the arm fixation method in the decubitus position, which varies among hospitals,[13-16] have focused on skin disorders[17,18] including pressure ulcers that may result from maintaining the same position for extended periods. However, few studies have investigated the relationship between optimal body positioning in the decubitus position during surgery and shoulder pain. Because Bando et al[8] have shown that patients with lung cancer who undergo surgery in the lateral decubitus position still experience multiple discomforts 6 months after surgery, we believe that the prevention of ISP, which is one of the causes of postoperative discomfort, contributes to the early recovery of postoperative patients and maintenance and improvement of their QOL. Therefore, we investigated the efficacy of a new upper limb fixation method—body pillow position for preventing postoperative ISP in patients undergoing lung resection.

Methods

At the time of surgery, various positions are set mainly for the purpose of facilitating the operation, but it is most important to ensure the safety of the patient.[19] To perform lung resection, the patient has to be placed in a lateral decubitus position because of the anatomic position of the lung.[14] When surgery is performed in the lateral decubitus position, it is necessary to fix the arm on the side of the surgery so that it does not fall off. A typical conventional arm fixation method is shown in Figure 1A. However, with this arm fixation method, there was a high incidence of ISPs, so this study compared the body pillow position (Figure 1B) with the conventional position (Figure 1A) to determine a safe and comfortable position for patients during lung resection. The primary endpoints were the frequency, severity, and duration of ISP after lung resection.

Patients and Recruitment

Eligible patients were adults diagnosed with lung cancer and lung tumors who underwent lung resection in the decubitus position at Tokushima University Hospital. Patients with one of the following conditions were excluded from the present study: (1) strong anxiety before surgery, (2) an inability to communicate or impaired cognitive function, (3) mental illness, (4) pre-existing shoulder pain, (5) a restricted range of motion in the shoulder before surgery, and (6) a body mass index (BMI) higher than 30.

The criteria for determining the sample size for statistical analysis were as follows: a two-tailed significance level of .05, a medium effect size of 0.3, and a statistical power of 0.8[20] in the intervention and control groups. The participants were assigned randomly into intervention and control groups, with 42 to 43 participants in each group. Figure 2 shows the enrollment algorithm in this study.

The Intervention and Control Groups

Patients provided informed consent and were assigned randomly into intervention and control groups on the day before surgery. The presence or the absence of the arm fixation method was a key component of the intervention. Each intervention was performed after general anesthesia in the operating room. In the arm fixation method group (group A), the upper limbs were positioned onto the arm fixation device. It is important that the upper limb is not abducted by more than 90° (to prevent hyperextension of the brachial plexus). The upper part of the limb was carefully restrained to prevent hyperextension of the elbow joint (to prevent ulnar nerve damage). In the body pillow group (group B), the upper arms were positioned with a body pillow. After the respiratory surgeon, anesthetist, and operating room nurse had positioned the patient's upper limbs (group B) before surgery commenced, the respiratory surgeon performed a final confirmation of the patient's upper limb position. The present study, particularly safety aspects, was fully explained to the respiratory surgeon, anesthetist, and

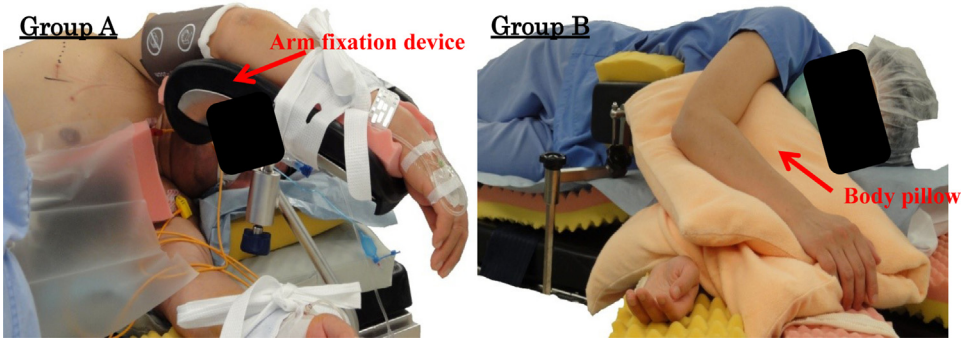

Figure 1. Arm fixation method on the surgical side. (A) Arm fixation method group (group A): the patient's arms are placed onto an arm fixation device. (B) Body pillow group (group B): the patient holds a body pillow in a natural manner. The red arrow shows the arm fixation device or body pillow. This figure is available in color online at www.jopan.org.

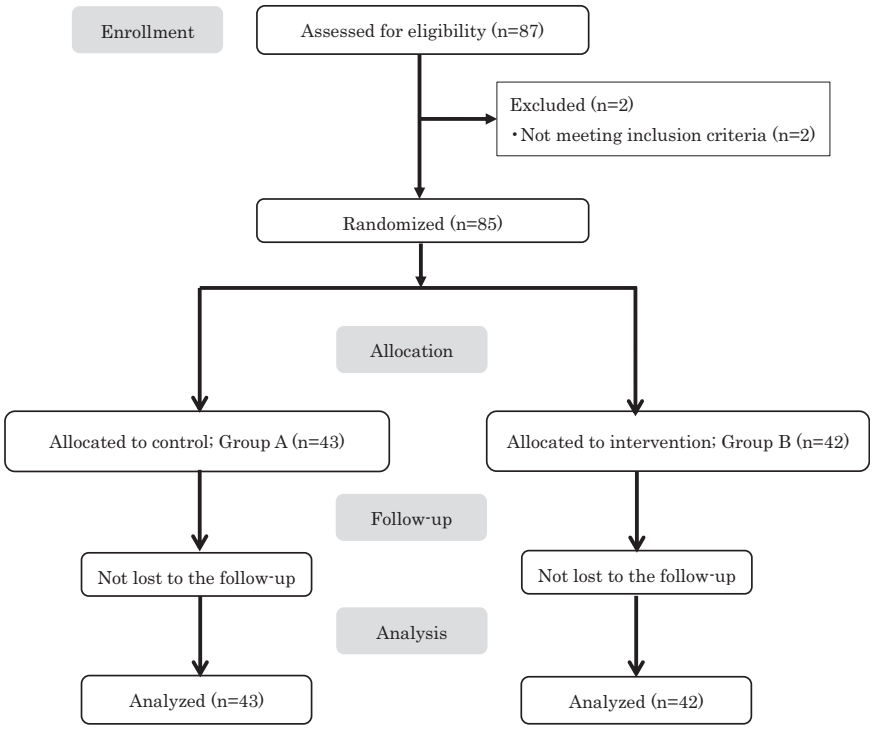

Figure 2. The enrollment algorithm for the arm fixation method.

operating room nurse. The arm fixation method on the surgical side is shown in Figure 1.

Hypothesis

In patients undergoing lung resection in the decubitus position, the frequency, severity, and duration of ISP after surgery will be lower in the body pillow position than in the traditional position using the arm fixation device.

Data Collection

Demographic and clinical variables were collected via a self-reported questionnaire and from medical records. The survey assessed basic demographic characteristics including age, sex, BMI, combined anesthesia (epidural/intravenous route), pre-existing shoulder stiffness (excluding shoulder pain), duration of surgery, and type of surgery. In this study, shoulder pain was defined as pain in the shoulder caused by a patient's position (decubitus position) during surgery and distinguished from shoulder stiffness, which has discomfort but not pain.

After hospitalization, patients were adequately informed of the study, and those who agreed to participate were interviewed. Patients were interviewed 2 days before surgery and once daily for 5 days after surgery. Before surgery, patients were asked about pre-existing shoulder pain or any restricted range of motion in the shoulder. After surgery, patients were questioned about the presence and severity of shoulder pain on the operative side that was not present before surgery. Because shoulder pain evaluated in this study is a subjective sensation, a 10-point NRS, ranging from 0 (the absence of shoulder pain) to 10 (worst shoulder pain), was used to evaluate the severity of shoulder pain in a quantifiable manner. Obesity (a high BMI) was previously suggested to be an onset factor for shoulder and upper limb pain in patients placed in the decubitus position during surgery[21]; therefore, BMI was added to the list of items evaluated. The duration of surgery, concomitant anesthesia (epidural/intravenous route), type of surgery, and other information were also obtained from medical records.

Ethical Considerations

The study was approved by the Clinical Research Ethical Review Board. Before the study, patients were informed of all necessary information regarding the publication of study data, both verbally and in writing. Patients were also provided with the following details: their privacy will be protected, there will be no treatment-related disadvantage regardless of whether the patient participates, they will not be identifiable from study data, and they may discontinue participating at any time. Patients who consented to these conditions were included.

The study was conducted on patients who were recovering from invasive procedures that caused marked mental and physical burdens. Thus, researchers conducted each interview after discussing the physical and mental conditions of the patients with the attending nurses, while carefully considering the mental and physical stresses of the interview on the patients and their physical condition.

Data Analysis

We conducted a descriptive analysis on patient characteristics, and the Shapiro-Wilk test was performed to evaluate the normality of quantitative data. If normality was not found, the results were expressed as medians and ranges, and the Mann-Whitney *U* test was performed. The Mann-Whitney *U* test was used to analyze differences in the duration of surgery and age of patients. Fisher exact test was performed on categorical data. It was used to analyze differences in sex, BMI (<25 vs ≥ 25), the presence or the absence of

combined anesthesia (epidural/intravenous route), shoulder stiffness (excluding shoulder pain) before surgery, and surgical procedures (standard surgery vs other types of surgery). The severity of shoulder pain (NRS) between the 2 groups was analyzed by a repeated-measures analysis of variance. Mauchly test was performed to test sphericity. Risk factors for ISP were examined by a logistic regression analysis. A multivariate analysis used backward selection and stepwise regression. The Hosmer-Lemeshow test was conducted to test the fitness of the model for a logistic regression analysis. Statistical analyses were performed using SPSS Statistics 23 for Windows (IBM SPSS Statistics; IBM Corporation). All items were evaluated using a significance level of 5% (two-tailed).

Results

Patient Characteristics

The enrollment algorithm for the arm fixation method is shown in Figure 2. Of 87 patients, two were excluded because their BMI was higher than 30. Therefore, 85 patients were randomly assigned to the traditional position using the arm fixation device (group A, $n = 43$) or body pillow position (group B, $n = 42$). All patients in each group were followed up and analyzed.

A summary of the sociodemographic and clinical characteristics of groups A and B is shown in Table 1. The median ages of groups A and B were 68.0 (32.0 to 84.0) years and 67.0 (46.0 to 85.0) years, respectively. There were 23 males (53.5%) in group A and 21 males (50%) in group B. The median duration of surgery was 223.0 (56.0 to 440.0) minutes in group A and 219.0 (60.0 to 512.0) minutes in group B. There were 28 patients with BMI less than 25 (65.1%) in group A and 30 (71.4%) in group B. Thirty-six patients (83.7%) in group A and 36 patients (85.7%) in group B received concomitant anesthesia. Pre-existing shoulder stiffness was noted in three patients (7.0%) in group A and five patients (11.9%) in group B. We defined lobectomy and pneumonectomy as standard surgeries. Standard surgery was performed on 20 patients (46.5%) in group A and 26 patients (61.9%) in group B. No significant differences were observed in age, duration of surgery, sex, BMI, concomitant anesthesia, pre-existing shoulder stiffness, or type of surgery between groups A and B. ISP developed in 11 patients (25.6%) in group A and 11 patients (26.2%) in group B. No significant differences were observed in the rate of ISP between groups A and B.

Changes in the Intensity of ISP (NRS Values) After Surgery in Groups A and B

The frequency of ISP was similar between groups A and B (Table 1). Figure 3 shows changes in the intensity of ISP (NRS) after surgery between groups A and B (group A; $n = 11$; group B; $n = 11$). The intensity of ISP between both groups was analyzed by a repeated-measures analysis of variance. Mauchly test was $P < .001$, and sphericity was not assumed; therefore, the degree of freedom was adjusted using the Greenhouse-Geisser method. Therefore, the intensity of ISP in 22 patients decreased over time ($P = .010$). The intensity of ISP on days 0 to 3 was slightly higher in group A than in group B.

Risk Factors for ISP

Twenty-two (25.9%) of 85 patients who underwent lung resection in the decubitus position developed ISP. As shown in Table 2, ISP developed in 11 patients (25.6%) in group A and 11 patients (26.2%) in group B. The univariate logistic regression analysis identified postoperative shoulder pain, the duration of surgery (minutes) (odds ratio [OR], 1.01; $P = .017$), pre-existing shoulder stiffness (excluding shoulder pain) (OR, 5.88; $P = .023$), and the type of surgery (OR, 0.34; $P = .047$) as risk factors for ISP. Significant variables were extracted using backward selection and stepwise regression. The result of the model χ^2 test was significant at $P < .01$, and the result of the Hosmer-Lemeshow test was $P = .975$. The percentage of correct classifications was 78.8%. The multivariate logistic regression analysis identified the duration of surgery

Table 1
Patient Characteristics in Groups A and B ($N = 85$)

Variables	Group A ($n = 43$)	Group B ($n = 42$)	*P*
	n (%)		
Age, y; median (range)	68.0 (32.0-84.0)	67.0 (46.0-85.0)	.80*
Duration of surgery; median (min) (range)	223.0 (56.0-440.0)	219.0 (60.0-512.0)	.53*
Sex			
Male	23 (53.5)	21 (50.0)	.83†
Female	20 (46.5)	21 (50.0)	
BMI			
<25	28 (65.1)	30 (71.4)	.64†
≥25	15 (34.9)	12 (28.6)	
Combined anesthesia (epidural/intravenous route)			
Used	36 (83.7)	36 (85.7)	1.00†
Not used	7 (16.3)	6 (14.3)	
Pre-existing shoulder stiffness (excluding shoulder pain)			
Present	3 (7.0)	5 (11.9)	.48†
Not present	40 (93.0)	37 (88.1)	
Type of surgery‡			
Standard surgery	20 (46.5)	26 (61.9)	.28†
Other types of surgery	23 (53.5)	16 (38.1)	
The presence of shoulder pain on the operated side			
Present	11 (25.6)	11 (26.2)	.15†
Not present	32 (74.4)	31 (73.8)	

BMI, body mass index.
* Mann-Whitney *U* test.
† Fisher exact test, significant difference $P < .05$ (two-tailed).
‡ Standard surgery versus other types of surgery (standard surgery: one-sided complete pneumonectomy, pneumonectomy, and lobectomy, other types of surgery: segmentectomy, partial resection, and exploratory thoracotomy).

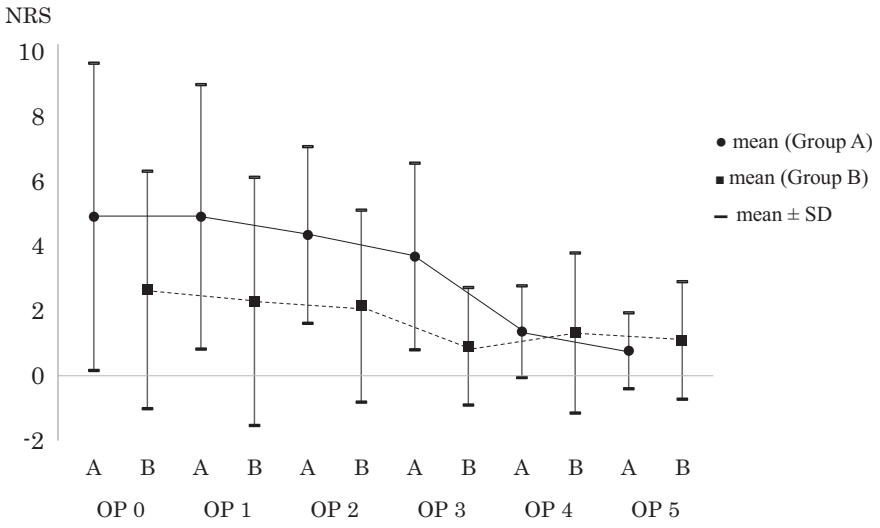

Figure 3. Changes in the intensity of shoulder pain (NRS values) in patients who developed ipsilateral shoulder pain on the operated side after surgery, mean. A: Arm fixation method group (group A) ($n = 11$, except OP 2) and B: body pillow group (group B) ($n = 11$, except OP 0, OP 1, and OP 2). NRS, numerical rating scale; OP, postoperative day.

(minutes) (OR, 1.01; 95% confidence interval, 1.00 to 1.01) and pre-existing shoulder stiffness (excluding shoulder pain) (OR, 5.15; 95% confidence interval, 1.07 to 24.83) as risk factors for ISP (Table 2).

Discussion

Because of advances in surgical and anesthetic techniques and instruments in recent years, VATS is regarded as a minimally invasive surgery. The advantages of VATS are a small skin incision, less postoperative pain,[6,22] shorter hospital stays,[22,23] and improved patient satisfaction.[22] Although the pain associated with skin incisions has been reduced by the minimal invasiveness of the VATS procedure, the incidence of ISP caused by the decubitus position remains between 31% and 75%.[4-8] Bando et al[8] previously reported that 30 (40.5%) of 74 patients who underwent lung resection in the decubitus position developed ISP. In the present study, ISP was noted in 11 patients (25.6%) in group A and 11 patients (26.2%) in group B, which was less than that reported in previous studies. Although many surgeons focus on reducing the size of skin incisions, the prevention of ISP should also be considered.

Several factors, such as the surgical procedure, surgical approach, patient positioning, and surgical time, have been shown to influence ISP.[6,11-13,15,16] Our previous study showed that two

Table 2
Results of the Logistic Regression Analysis Examining Risk Factors for Postoperative Shoulder Pain

Variables	Number of Patients	Pain Incidence	Univariate Analysis			Multivariate Analysis		
		n (%)	OR	95% CI	*P*	OR	95% CI	*P*
All	85	22 (25.9)	—	—	—	—	—	—
Group								
A	43	11 (25.6)	1 (Reference)					
B	42	11 (26.2)	1.03	0.39-2.72	.949			
Age (y)	85		0.98	0.94-1.02	.374			
Sex								
Male	44	12 (27.3)	1 (Reference)					
Female	41	10 (24.4)	0.86	0.45-1.82	.782			
BMI								
<25	58	15 (25.9)	1 (Reference)					
≥25	27	7 (25.9)	1.00	0.35-2.83	.995			
Pre-existing shoulder stiffness (excluding shoulder pain)								
Not present	77	17 (22.1)	1 (Reference)			1 (Reference)		
Present	8	5 (62.5)	5.88	1.28-27.15	.023*	5.15	1.07-24.83	.041*
Duration of surgery (min)	85	Continuous	1.01	1.00-1.01	.017*	1.01	1.00-1.01	.030*
<5 h	67	14 (20.9)	1 (Reference)					
≥5 h	18	8 (44.4)	3.03	1.01-9.10	.048*			
Combined anesthesia (epidural/intravenous route)								
Used	72	21 (29.2)	1 (Reference)					
Not used	13	1 (7.7)	4.94	0.60-40.45	.136			
Type of surgery†								
Limited surgery	39	6 (15.4)	0.34	0.12-0.99	.047*			
Standard surgery	46	16 (34.8)	1 (Reference)					

OR, odds ratio; 95% CI, 95% confidence interval; BMI, body mass index.
Multivariate analysis: backward selection and stepwise regression.
* Significant difference $P < .05$.
† Standard surgery versus other types of surgery (standard surgery: one-sided complete pneumonectomy, pneumonectomy, and lobectomy, other types of surgery: segmentectomy, partial resection, and exploratory thoracotomy).

factors, the duration of surgery and pre-existing shoulder stiffness, influenced the development of ISP on the operative side.[8] In the present study, the univariate logistic regression analysis identified the duration of surgery, pre-existing shoulder stiffness, and the type of surgery as risk factors of ISP, and the duration of surgery and pre-existing shoulder stiffness remained as significant factors in the multivariate logistic regression analysis. The present results are consistent with our previous findings. Therefore, the duration of surgery and pre-existing shoulder stiffness are important predictive factors for the development of ISP. Previous studies demonstrated that standard lung resection (lobectomy/pneumonectomy) was associated with a high incidence of ISP.[6,24] The importance of the surgical approach (thoracoscopic vs open surgery) remains controversial.[6,22-24]

Double-blinded randomized studies have been conducted on anesthetic treatments for ISP using thoracic epidural anesthesia, suprascapular nerve block, and interscalene brachial plexus block[5]; however, few have investigated preventive positioning during surgery for ISP. We performed a randomized clinical trial on the traditional position versus the body pillow position to prevent ISP. The frequency of ISP in both positions was similar, whereas the intensity of ISP in the body pillow position was lower than that in the traditional position. The etiology of ISP currently remains unclear.[3]

ISP is regarded as referred pain from the phrenic nerve,[5,12,25,26] muscle strain from positioning, or surgical damage to ligaments and muscles.[10-13] Mark and Brodsky[11] speculated that ligament and muscle damage caused by positioning, but not referred pain from the phrenic nerve, strongly contributes to the development of ISP because frequent exercise of the affected arm and shoulder aggravated ISP. We also consider ISP to be caused by ligament and muscle damage because of positioning but not referred pain from the phrenic nerve. Hirai et al[13] speculated that inner rotation and adduction of the affected arm may prevent and/or reduce ISP, whereas external rotation and abduction exerts the opposite effects. The use of a body pillow for fixation of the upper limb (group B) facilitates the fixation of the affected upper limb to the inner rotation and adduction position (group A). We considered that internal rotation and adduction may reduce the frequency and intensity of ISP and examined an effective upper limb fixation method—body pillow position for the prevention of ISP between 2 groups (group A vs group B). However, the frequency of ISP in both positions was similar, there was no statistical difference between the two groups. The intensity of ISP on postoperative days 0 to 3 was slightly lower in group B than group A, but there was no statistical difference. It is important for perioperative care providers to prevent ISP for early postoperative recovery and improvement of postoperative QOL. These results suggested that we must consider a better position for preventing postoperative ISP in patients undergoing lung resection in the future.

Tanyong et al[27] recently showed that the intravenous administration of parecoxib before surgery reduced the intensity of ISP. We generally favor prophylactic procedures over medication. The prevention of ISP by using a better perioperative posture fixation method without prophylactic medication will be advantageous for patients. If medical staff, including doctors and nurses, note that patients have pre-existing shoulder stiffness or will be subjected to surgery of a long duration, appropriate body positioning during surgery needs to be considered. If the postoperative ISP can be prevented by the appropriate position during the operation, it can contribute to the prevention of postoperative discomfort of the patient and reduction of health expenditures. For perioperative care providers, it is important to search for care methods to establish the safe upper limb fixation methods with less burden to the patient to prevent postoperative ISP in the pursuit of early postoperative recovery and improvement of postoperative QOL.

Limitations

The intensity of ISP in the body pillow position was slightly lower than that in the traditional position. The incidence of ISP ranges between 31% and 75%.[4-8] We previously showed that 30 (40.5%) of 74 patients who underwent lung resection in the decubitus position developed ISP; however, ISP only developed in 22 cases (26%) after surgery in the present study, and there was no statistical difference in the incidence of ISP between the two groups (group A vs group B). The intensity of ISP was slightly lower in the upper limb fixation method using a body pillow than in the traditional upper limb fixation method on postoperative days 0 to 3, but there was no statistical difference. The lack of significant differences in the intensity of ISP between the two groups may be due to the shortage of cases with ISP.

Conclusions

Although advances in anesthesia and surgical techniques have greatly contributed to the early recovery of postoperative patients, there are patients who complain of ISP of unknown origin after surgery. The emergence of ISP may reduce the QOL of patients after surgery, even if pain from surgical wounds is managed successfully. The prevention of ISP by using a better perioperative posture fixation method without prophylactic medication will be advantageous for patients. Therefore, it is considered that the prevention of ISP by the cooperation of medical personnel involved in perioperative medical care can greatly contribute to the early postoperative recovery. Further randomized controlled trials are needed to confirm the efficacy of arm fixation for ISP prevention in patients undergoing surgery in the decubitus position other than lung resection.

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