1. **Title:** Ipsilateral shoulder pain in patients following lung resection in the decubitus position.

2. **A running head:** Shoulder pain in patients following lung resection

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ABSTRACT

Aim and objective. The purpose of this study was to examine the frequency, influencing factors, and clinical course of shoulder pain in patients following lung resection.

Background. Thoracoscopes have been introduced in the surgical treatment of lung cancer, and allow for less invasive surgery with a minimal incision. However, decubitus position-related shoulder pain on the operated side has not yet been investigated.

Design. A longitudinal descriptive study.

Methods. Patients who underwent lung resection in the decubitus position. Patients were interviewed 2 days before surgery and once daily for 5 days after surgery. Interview items included background data, the concomitant use of epidural anesthesia, operative duration, presence of preoperative shoulder stiffness (excluding shoulder pain), type of surgery, and site of operation. The intensity of pain was approximately 5 on an 11-point numerical rating scale. Descriptive statistics on patient backgrounds were obtained using SPSS Statistics 22 for Windows.

Results. Of the 74 patients who underwent lung resection in a decubitus position, 30(40.5%) developed shoulder pain on the operated side. The highest rating occurred 1 day after surgery and decreased over time. The following two factors

were found to influence shoulder pain on the operated side: operative duration(Z=-2·63;p=0·01), and presence of preoperative shoulder stiffness(excluding shoulder pain)($\chi^2 = 4 \cdot 16$;p=0·04).

Conclusions. This study demonstrated that approximately 40% of patients who underwent lung resection in the decubitus position developed shoulder pain.

Relevance to clinical practice.

The presence of postoperative shoulder pain was related to both the duration of the operation and to the presence of preoperative shoulder stiffness. Although the shoulder pain resolves within 4 days, it causes the patient additional discomfort and distress. Therefore, further research is needed on positioning for thoracotomy in order to investigate ways to reduce or eliminate this complication of lung surgery.

Keywords: lobectomy, decubitus position, post-surgery, shoulder pain on the operated side

What does this paper contribute to the wider global clinical community?

·This study shows that ipsilateral shoulder pain in patients following lung resection in the decubitus position is approximately 40% and rated as 5.10 on the 11-point NRS, which warrants greater attention by clinical professionals.

・To clarify relevant factors of ipsilateral shoulder pain in the decubitus position, the point of view of preoperative risk assessment is clarified and becomes possible to prevent ipsilateral shoulder pain caused by invasion other than surgical wounds.

Introduction

Recent advances have enabled less invasive surgical procedures and improved perioperative management techniques, which are beneficial to patients undergoing lung resection. These advances have contributed to the postoperative recovery and early ambulation of patients by minimalizing the pain associated with thoracotomy including the skin incision and muscle resection (Uchimura et al.2000, hara et al.2017). However, patients often develop shoulder pain, which is due to the decubitus position used for lung resection (Hashimoto et al.2004, Sato et al.1996).

Background

To perform lung resection, the patient has to be placed in a lateral decubitus position due to the anatomical position of the lung (Ichiryu.1994). A thick sponge, such as Soft-nurse®, is used to fix the posture in order to prevent pressure ulcer so that the shoulder under the body is protected (Hara et al.2013).

On the other hand, the shoulder, upper arm, forearm, and hand on the surgical side are immobilized with an armrest to secure the surgical field and prevent falls, and are inevitably retained in the same posture for a prolonged period. We frequently hear complaints of shoulder pain on the surgical side from patients after lung resection (Burgess FW et al.1993). Postoperative pain control of the incised skin region has recently been actively performed employing thoracic epidural block, but it is not sufficiently effective for shoulder pain, and no appropriate method has been established (Goto et al.2010,Hanna et al.2014,Mikami et al.2014,Fardin et al.2016). We previously reported shoulder pain on the operated side 1 month after surgery in approximately 20% of patients (Bando et al.2015). Although the minimally invasive surgical procedure currently used has improved the pain associated with thoracotomy, it does not ameliorate shoulder pain caused by the decubitus position. Patients must remain in the decubitus position during surgery for an adequate field of vision and safe and effective operative procedures. Therefore, shoulder pain caused by surgical body positioning needs to be minimized. However, few studies have investigated the relationship between optimal body positioning in the decubitus position during surgery and shoulder pain.

McCaffery reported that “pain is whatever the experiencing person says it is, existing whenever the experiencing person says it does” (McCaffery et al.1989),

namely, pain is a subjective sensation at all times. Although patients may have pain, individuals other than the patients themselves may not recognize it. Medical staff, particularly nurses, need to be able to detect patient pain and discomfort. Staff are aware of the pain associated with thoracotomy, but not ipsilateral shoulder pain. The purpose of this study is to clarify the factors influencing ipsilateral shoulder pain in patients following lung resection in the decubitus position, and to describe the clinical course of this postoperative complication.

<Operational definitions of terms>

Shoulder pain: shoulder pain caused by a patient's position (decubitus position) during surgery.

Before surgery: In this study, 2 days before surgery.

Methods

Design

A longitudinal descriptive study

Subjects

Patients who underwent lung resection in the decubitus position at Tokushima University Hospital were eligible. The following patients were excluded from

this study: patients with mental instability observed before surgery, patients with an inability to communicate or those with impaired cognitive function, patients with mental illness, patients with shoulder pain before surgery, and patients with a restricted range of motion.

Procedure

Method used to restrain a patient in the decubitus position

While ensuring an adequate field of vision and paying careful attention to the position of both legs, the upper limb on the side to be operated on was restrained using an armrest (Figure 1). The upper part of the limb was carefully restrained to prevent hyperextension of the elbow joint (to prevent ulnar nerve damage). In addition, the upper limb was not abducted more than 90º (to prevent hyperextension of the brachial plexus).

Evaluation items and method of measurement

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. Interviews were conducted in the afternoon (between 14:00 and 16:00).Interview items included background data, the concomitant use of epidural anesthesia, operative duration, presence of preoperative shoulder stiffness (excluding shoulder pain), type of surgery, and site of operation. In a previous study, a high obesity index was

suggested to be an onset factor for shoulder and upper limb pain in patients placed in the decubitus position during surgery (Sato et al.1996); therefore, body mass index (BMI) was added to the list of items evaluated. The operative duration, type of surgery, site of operation, and other information were obtained from doctors in charge or electronic medical records.

Shoulder pain before and after surgery

Before surgery, the patient was questioned on the presence of shoulder pain and any restricted range of motion in the shoulder. After surgery, the patient was questioned on the presence and severity of shoulder pain on the operated side that was not present before surgery.Since shoulder pain evaluated in this study is a subjective sensation, an 11-point numerical rating scale (NRS), ranging from 0 (absence of shoulder pain) to 10 (worst shoulder pain), was used to evaluate the severity of shoulder pain in a quantifiable manner.

Method of data analysis

Descriptive statistics on patient characteristics were obtained using SPSS Statistics 22 for Windows（IBM SPSS Statistics, IBM Corporation, U.S）and the Shapiro-Wilk test was performed to evaluate the normality of quantitative data. The Mann-Whitney U test was used to analyze the difference in the operative time between 2 groups divided based on the surgical procedure (lobectomy vs.

other surgery) and differences in the age and operative time between 2 groups divided based on the presence or absence of postoperative shoulder pain. In the present study, the patients were divided into 2 groups with and without the development of shoulder pain by day 5 after surgery. In addition, Pearson's chi-square test was employed to compare 2 groups divided based on the sex, BMI, and presence or absence of contaminant anesthesia, shoulder stiffness (excluding shoulder pain) from before surgery, and surgical procedure (lobectomy vs. other surgery). The Wilcoxon signed-rank test was performed as to changes in the intensity of shoulder pain (NRS values) in patients who developed shoulder pain on the operated side after surgery. All items were evaluated using a significance level of 5% (two-tailed).

Ethical consideration

This study was approved by the Clinical Research Ethical Review Board of Tokushima University Hospital. Prior to the study, subjects were informed of all necessary information regarding the publication of the study data, both verbally and in writing. Participants were also provided with the following details: the privacy of the study subject will be protected, there will be no treatment-related disadvantage regardless of whether the patient participates in the study, the study subject will not be identifiable from study data, and the study subject may

discontinue participating at any time. Patients who consented to these conditions were included in the study.

This study was conducted on patients who were recovering from invasive treatment associated with significant mental and physical burdens. Thus, the investigators conducted each interview after discussing the physical and mental conditions of the patient with the attending nurses, while carefully considering the mental and physical stresses of the interview on the patient and the patient's physical condition.

Results

Patient characteristics in this study

Table 1 shows the characteristics of patients in this study. Among the patients who were asked to participate, consent was obtained from 74 patients. The patients in this study consisted of 45 men (60·8%) and 29 women (39·2%), and their mean age was 66·7±12·0 years. The mean operative time was 239·0±115·0 minutes. For the lobectomy group mean operative time was 279·5±96·7 minutes compared with 185·8±116·7 minutes in the other surgery group (segmentectomy, partial resection, exploratory thoracotomy). Thus, the operative duration was significantly longer in the lobectomy group ($Z=-3·59$; $p<0·01$).Fifty-four patients (74%) underwent lobectomy. Preoperative shoulder stiffness (excluding

shoulder pain) existed in 10 patients (13·5%). Acute shoulder pain was reported from 1 day after surgery (OP1) to 5 days after surgery (OP 5) in 30 patients (40·5%). The mean duration of shoulder pain was 2·97±1·73 days. In 14 patients (18·9%), a poultice was used to treat shoulder pain. All patients were admitted to the HCU ward for 1 to 2 days after surgery for systemic management.

Clinical findings of patients with and without shoulder pain

Table 2 shows the clinical findings of patients with and without shoulder pain. The operation time of patients with shoulder pain (pain group) was significantly longer than that of patients without shoulder pain (no pain group) (282·4±107·7 vs 209·3±111·3, Z=-2·63;p=0·01). The number of patients with preoperative shoulder stiffness in the pain group was significantly higher than that in the no pain group (23·3% vs 6.8%,χ^2＝4·16;p=0·04).

Change in the intensity of shoulder pain (NRS values) after surgery in patients who developed shoulder pain on the operated side.

Figure 2 shows changes in the intensity of shoulder pain (NRS values) after surgery in patients who developed shoulder pain on the operated side (n=30). The intensities of shoulder pain on days 1, 2, 3, 4, and 5 after surgery were respectively decreased (Figure 2). A significant difference was observed in

shoulder pain between day 1 and day 2(Z=-2·23; p=0·03), day 1 and day 3(Z=-2·79; p=0·01), and day 1 and day 4(Z=-3·94; p<0·01), day 1 and day 5(Z=-4·03; p<0·01). However, no significant difference was noted in shoulder pain between day 4 and day 5(Z=-1·47; p=0·14). A significant difference was observed in shoulder pain between day 1 and day 2(Z=-2·23; p=0·03) and also between day 3 and day 4(Z=-2·05; p=0·04). 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.

Discussion

In lung resection, the skin incision size, resection size of the muscles and parietal pleura, and the procedure of widening the intercostal space during surgery are associated with postoperative pain. In order to reduce postoperative pain, a less invasive surgery with a thoracoscope and the concomitant use of epidural anesthesia are now commonly used. Previous studies focused on the pain of the skin incision and resection of muscles, but not shoulder pain. We previously reported that approximately 20% of patients with lung resection developed shoulder pain due to the decubitus position for lung resection (Bando et al.2015). The number of patients with shoulder pain was higher in the present study than in the previous study (40% vs 20%). The maximum intensity of

shoulder pain was rated as 5·10±3·75 on the 11-point NRS. Considering its frequency and intensity, attention should be paid to shoulder pain in the lateral decubitus position as a perioperative problem after lung resection.

In the present study, a statistical analysis of shoulder pain revealed a significant difference in shoulder pain between OP1 and OP4 and also between and day 4. No significant difference was observed in shoulder pain between day 4 and day 5. The maximum intensity of shoulder pain was observed on day 1 (5·10). Shoulder pain gradually decreased with time (day 1-day 3, 5·10 to 2·33), and improved on day 4-5 (1·29-0·91). Moore previously reported that this period corresponds to the acute injury phase in which the strongest stress reactions are observed in postoperative patients (Goto et al.2010). Thus, not only skin incision pain, but also shoulder pain may hinder the physical and mental recoveries of patients. “Shoulder stiffness is a manifestation of pain associated with decreased blood circulation, mainly noted in the trapezius muscle, due to accumulated fatigue or prolonged bad posture (Michimori et al.2008)”.The presence of postoperative shoulder pain was attributed to 2 clinical factors: the operative duration (Z=-2·63;p=0·01) and presence of preoperative shoulder stiffness($\chi^2 = 4{\cdot}16$;p=0·04). The incidence of shoulder pain in patients who underwent lobectomy was slightly higher than that in patients who underwent segmentectomy and partial resection. Lobectomy is a

standard and curative surgery for lung cancer (Nakagawa et al.2006). In this study, the mean operative duration was 279·5±96·7 minutes in the lobectomy group and 185·8±116·7 minutes in the reduction surgery group. Thus, the operative duration in the lobectomy group was significantly longer than that in the reduction surgery group. The operation time of patients with shoulder pain was significantly longer than that of patients without shoulder pain (282·4±107·7 versus 209·3±111·3, Z=-2·63;p=0·01). The operative time is linked to the type of surgery performed. A long operative time leads to the patient remaining in the same position for a longer period and, thus, increases the risk of shoulder pain.

In patients with preoperative shoulder stiffness, the incidence of shoulder pain was significantly increased. Preoperative shoulder stiffness may be a high risk factor for postoperative shoulder pain. Therefore, a good positioning without postoperative shoulder pain as nursing care for these patients should be considered and confirmed by a clinical research.

At the time of surgery, a patient is typically restrained in a position that is convenient for surgeons to perform surgery; however, the first priority needs to be securing the safety of the patient (Perioperative management team text.2016). Therefore, healthcare workers need to have correct knowledge on the factors contributing to the complications associated with a patient’s position during

surgery (Perioperative management team text.2016). Regarding the method of restraining a patient in the decubitus position, many key points and procedures have been published by the Japan Operative Nursing Academy and other organizations (Rose.1985 &Hanaoka et al.2003). However, only a limited number of studies have been conducted on the factors related to the onset of shoulder pain in the decubitus position, and a consensus has not yet been obtained (Hashimoto et al.2004,Sato et al.1996).

Conclusion

This study demonstrated that approximately 40% of patients who underwent lung resection in the decubitus position developed shoulder pain. The maximum intensity of shoulder pain was rated as 5.10 on the 11-point NRS. The maximum intensity of shoulder pain was observed on day 1 and gradually decreased with time (day 1-day 3). Shoulder pain improved on day 4-5.

Relevance to clinical practice

The presence of postoperative shoulder pain was related to both the duration of the operation and to the presence of preoperative shoulder stiffness. Although the shoulder pain resolves within 4 days, it causes the patient additional discomfort and distress. Therefore, further research is needed on positioning for

thoracotomy in order to investigate ways to reduce or eliminate this complication of lung surgery. In the future, we need to consider a method for restraining the upper limb in the decubitus position that reduces shoulder pain.

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Conflict of interest

None.

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Figure legends

Figure 1: Method to restrain patients in the decubitus position on an operating table. Red arrows show an armrest.

Figure 2: Changes in the intensity of shoulder pain (NRS values) in patients who developed shoulder pain on the operated side after surgery. The Wilcoxon signed-rank test was performed. NRS: Numerical Rating Scale.

Figure 1.

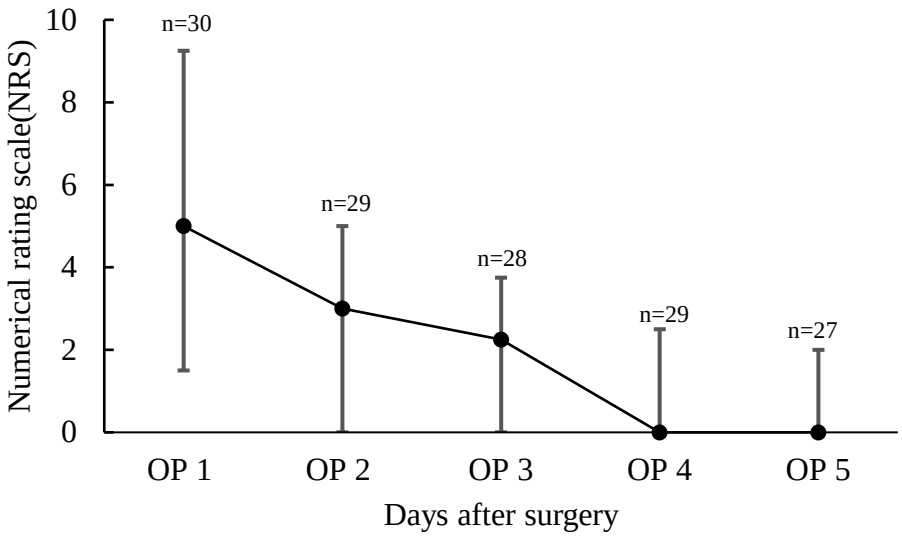

Figure 2　Change in the intensity of shoulder pain (NRS values) in patients who developed shoulder pain on the operated side after surgery. The Wilcoxon signed-rank test was performed. NRS, numerical rating scale

Table 1: Characteristics of the patients in this study (n＝74)

	n	%
Age[a] (years)		66.7±12.0
Operative duration[a](minutes)		239.0±115.0
Lobectomy vs Other surgery types[b]		279.5±96.7 vs 185.8±116.7 (Z=-3.59, p<0.01)[b]
Gender		
Men	45	60.8
Women	29	39.2
BMI		
> 25	53	71.6
≤ 25	21	28.4
Combined anesthesia (epidural/intravenous route)		
Used	64	86.5
Not used	10	13.5
Preoperative shoulder stiffness(excluding shoulder pain)		
Present	10	13.5
Not present	64	86.5
Type of surgery		
Lobectomy	54	74.0
Other type of surgery	20	26.0
Presence of shoulder pain on the operated side		
Present	30	40.5
Not present	44	59.5
Duration of acute postoperative shoulder pain (days) (from OP1 to OP5)		2.97±1.73[a]
Use of a poultice in the shoulder area (at least once from OP1 to OP 5)		
Used	14	18.9
Not used	60	81.1

[a]mean±SD.

[b]Mann-Whitney U test for differences between two surgery group (Lobectomy vs Other surgery types).

Lobectomy :standard surgery group;other surgery types :reduction surgery group (segmentectomy, partial resection, exploratory thoracotomy).

Table 2: Clinical findings of the patient with and without shoulder pain (n=74)

	Patients with shoulder pain* (n=30)		Patients without shoulder pain (n=44)			
	n	%	n	%	$Z^{b)}$／χ^{2b}	p
Age[c] (years)	66.2±11.9		66.9±12.2		-4.08	.68
Operative duration[c] (min)	282.4±107.7		209.3±111.3		-2.63	.01*
Gender						
Men	21	70.0	24	54.5	1.79	.18
Women	9	30.0	20	45.5		
BMI						
> 25	21	70.0	32	72.7	0.07	.79
≤ 25	9	30.0	2	27.3		
Combined anesthesia (epidural/intravenous route)						
Used	26	86.7	38	86.4	0.00	.97
Not used	4	13.3	6	13.6		
Preoperative shoulder stiffness(excluding shoulder pain)						
Present	7	23.3	3	6.8	4.16	.041*
Not present	23	76.7	41	93.2		
Type of surgery						
Lobectomy	21	70.0	21	47.7	3.60	.058
Other type of surgery	9	30.0	23	52.3		
Use of a poultice in the shoulder area (at least once from OP1 to OP 5)						
Used	14	46.7	0	0		
Not used	16	53.3	44	100		

Lobectomy :standard surgery group, Other surgery types :reduction surgery group (segmentectomy, partial resection, exploratory thoracotomy)

[a]Mann-Whitney U test for differences between two surgery group(Lobectomy vs Other surgery types)

[b]Pearson's Chi-square test

[c]mean±SD.

*P＜.05.