A Thesis
for The Degree of Master of Science

The Effect of Sodium Carboxymethylcellulose on Prevention of Postoperative Pleural and Pericardial Adhesions in Dogs

Dongkyu Jung

Department of Veterinary Medicine
Graduate School, Cheju National University

2000. 2

The Effect of Sodium Carboxymethylcellulose on Prevention of Postoperative Pleural and Pericardial Adhesions in Dogs

Dongkyu Jung
(Supervised by professor Jongtae Cheong)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Veterinary Medicine.

1999. 12.

This thesis has been examined and approved.

Thesis director, Kyungkap Lee, Prof. of Veterinary Medicine

Myungbok Wie, Prof. of Veterinary Medicine

Jongtae Cheong, Prof. of Veterinary Medicine

2000. 2.

Department of Veterinary Medicine
GRADUATE SCHOOL
CHEJU NATIONAL UNIVERSITY

Contents

The Effect of Sodium Carboxymethylcellulose on Prevention of Post-operative Pleural and Pericardial Adhesions in Dogs

Dongkyu Jung

(Supervised by Professor Jongtae Cheong)

Department of Veterinary Medicine
Graduate School, Cheju National University
Cheju, Korea

Abstract

Pleural and pericardial adhesions are very common post-operative complications in intra-thoracic operations in dogs. The purposes of this study are to evaluate the efficacy of 1% sodium carboxymethylcellulose (SCMC) to prevent postoperative pleural and pericardial adhesions, to determine the effective dose of 1% SCMC in intra-thoracic surgery, and to find common adhesive structures after intra-thoracic operation in the dog. The experimental design was a randomized complete block design with five treatments in two blocks (saline-treated & SCMC-treated group). Adhesions were induced by abrasion in the pleura and pericardium. 1% SCMC and saline were then instilled into the pleural cavity respectively (3.5ml/kg). On the 30th day after the operation, the extents of adhesions were measured according to the severity from 0 to 4 points. The plasminogen concentration and complete blood counts (CBC) were evaluated in the pre- and post-operative period.

Adhesion scores from the viscera to parietal pericardium were 3.7 in animals treated with normal saline and 2.4 in animals treated with 1% SCMC ($p<0.01$). Mean scores from the lung lobes were 3.5 in saline-

treated group and 1.7 in SCMC-treated group ($p<0.01$). In addition, adhesions between the pericardium and sternum were more frequently formed than in the other pleural surface in saline-treated group (3.6) and SCMC-treated group (2.8). These results suggest that the application of 1% SCMC during intra-thoracic operation could be beneficial to prevent pleural and pericardial adhesions, and it would reduce the technical difficulty and the risk in repeated cardiac surgical procedures.

Key words: Dog, Pleurum, Pericardium, Adhesion, SCMC, Intra-thoracic

Ⅰ. Introduction

Adhesions across the pericardial space are a common complication of cardiac operation (Cliff *et al.*, 1973). Although the previous formation of dense adhesions between the heart and the surrounding tissues does not result in immediate or obvious morbidity, repeated cardiac surgical procedures are associated with increased technical difficulty for the surgeon and increased risk because of the adhesions. Also, these complications may result in serious secondary complications and disease such as atelectasis and torsion of lung lobe (Cliff *et al.*, 1973; Cunningham Jr. *et al.*, 1975; Ikäheimo *et al.*, 1985; Boggs and Kinasewitz, 1995).

Suspected causes of the pleural adhesions are concurrent appearances of spilled blood (Robinson, 1987), mesothelial injuries such as drying of pleural membrane, and inflammatory response activation by spilled blood (Cliff *et al.*, 1973; Boggs and Kinasewitz, 1995).

Currently, many experiments and studies have been performed to prevent thoracic and pericardial adhesions. The pharmacological basis for adhesion prophylaxis includes agents that decrease the inflammatory reaction (Beauchamp *et al.*, 1984; Xie *et al.*, 1998), prevent blood coagulation and fibrin deposition (Strange *et al.*, 1995), promote fibrinolysis (Wiseman *et al.*, 1992; Hill-West *et al.*, 1995), mechanically separate the injured tissues (Youmans *et al.*, 1968; Laks *et al.*, 1981; Robinson *et al.*, 1984; Milgalter *et al.*, 1985; Rein and Hill, 1989) , close the pericardium with loose suture and insert the chest tubes (Cunningham Jr. *et al.*, 1975; Nandi *et al.*, 1976).

Sodium carboxymethylcellulose (SCMC) is a high molecular weight polysaccharide polymer that is water soluble, biocompatible and viscous (Elkins *et al.*, 1984). It is thought that these substances act through a mechanical flotation method separating viscera by a physical barrier (Fredericks *et al.*, 1986; Ryan and Sax, 1995).

The purposes of this study are to evaluate the efficacy of 1% SCMC to prevent postoperative pleural and pericardial adhesions, to determine the effective dose of 1% SCMC in intra-thoracic surgery, and to find common adhesive structures after intra-thoracic operation in the dog.

Ⅱ. Materials and Methods

1. Experimental animals:

Ten mongrel dogs weighing between 5 to 10 ㎏ of body weight were assigned to two groups at random. Each group consisted of 5 dogs. Food and water were available *ad libitum*.

To determine previous diseases of the dogs, physical examinations and complete blood counts (CBC) were performed.

The SCMC were prepared as 1 percent by weight per volume of distilled water. All were sterilized by autoclaving.

2. Experimental procedure:

Preparing and Premedication:

CBC and plasminogen concentrations were evaluated before the experimental operation. Broad spectrum antibiotic was given to the dog two hours before surgical procedure intramuscularly and atropine sulfate (0.05 ㎎/㎏ of body weight) was injected intramuscularly before the operation. Skin of the dog was prepared with 70% isopropyl alcohol and povidone-iodine.

2-1. *Induction of general anesthesia:*

General anesthesia was induced with intravenous thiopental sodium (Pentothal®, 10～15 ㎎/㎏ of body weight). After the animal was anesthetized, endotracheal intubation was immediately done and inhalation of oxygen was allowed 3～5 minutes to sufficient oxygenation and "lung washout". Draping in a sterile fashion was performed during anesthesia.

2-2. *Anesthesia maintenance:*

After the animal had general anesthesia, a combination of N_2O (120 ㎖/㎏

/min) and oxygen (200 ㎖/㎏/min) was allowed to be inhaled in the semi-open circuit system. Stage Ⅲ surgical anesthesia was maintained with nitrous oxide, oxygen, and enflurane. Ancillary respiratory support (PEEP) was performed during the operation.

2-3. *Operative procedure:*

In sterilized conditions, median sternotomy was performed with an oscillating bone saw. Unexpected bleeding was immediately controlled with electrocautery, and careful attention was given to prevent the spilling of blood into the thoracic cavity. After opening the thorax, the costal pleurum between the 4th to 6th intercostal spaces was then abrased bilaterally with dry gauze sponge. After the pleural abrasion, pericardium was incised longitudinally from apex to base of the heart, about 1 cm anterior to the left phrenic nerve. Vigorous rubbing of visceral and parietal pericardium with a dry gauze sponge was then done. Each abrasion was 2 ㎝ × 2 ㎝. Instillation of 0.9% sterilized normal saline (3.5 ㎖/㎏) into the pleural and pericardial space then done in saline-treated group, but irrigation of sterilized 1% SCMC (3.5 ㎖/㎏) was performed into the thoracic cavity in SCMC-treated group. Then, the thorax was closed without closing the opened pericardium

The incised sternum was sutured with orthopedic stainless steel wire (1-0). The muscle and subcutaneous tissue was closed in layers with 2-0 chromic catgut suture. Finally, the skin was closed with surgical nylon (2-0) by simple interrupted pattern.

2-4. *Evaluation of CBC and plasma plasminogen concentration*

Each animal was evaluated using a CBC by every 3 days after surgery for 30 days, but plasminogen concentration was determined on the 1st, 3rd, 5th day after the operation. Blood samples were obtained from cephalic vein in the dogs. Fibrinogen and total protein were evaluated by refractometer. RBC counts, WBC counts were determined manually by hemocytometer. PCV

value was evaluated by microhematocrit method. Plasma plasminogen concentration was evaluated using chromogenic plasminogen kit (Accucolor™ Sigma, USA).

2-5. *Evaluation of adhesions*

Each dog was sacrificed on the 30th day after the operation. Two persons who were unaware of the operation schedule and application evaluated severity of the adhesions. Evaluation was performed by scoring 0 to 4 point according to severity of the adhesions (Table 1). In addition, predominant adhesion sites of the thoracic organs were classified and determined.

2-6. *Statistical analyses*

Scores from each group were compared using t-test and ANOVA. Hematological values were analyzed using t-test. Determination of common adhesion formation structure analyzed using ANOVA.

Table 1. Classification of Adhesion Scores

Adhesion score	Observation
0	No adhesions
1	Filmy adhesions with easily identifiable plane
2	Mild adhesions with freely identifiable plane
3	Moderate adhesions with difficult plane of dissection
4	Dense adhesions with no plane of dissection

- Derived from" Prevention of pericardial adhesions using tissue protective solutions" by Seeger *et al.* (1997)

Ⅲ. Results

1. Adhesion score

Mean adhesion score in saline-treated group and SCMC-treated group, is shown in the figure 1. Mean adhesion score in saline-treated group (3.7) was much higher than that of SCMC-treated group (2.4) in the pericardium ($p<0.01$). Mean adhesion score in the pleurum with the lung lobe also significantly differs between saline-treated group (3.5) and SCMC-treated group (1.7) ($p<0.01$).

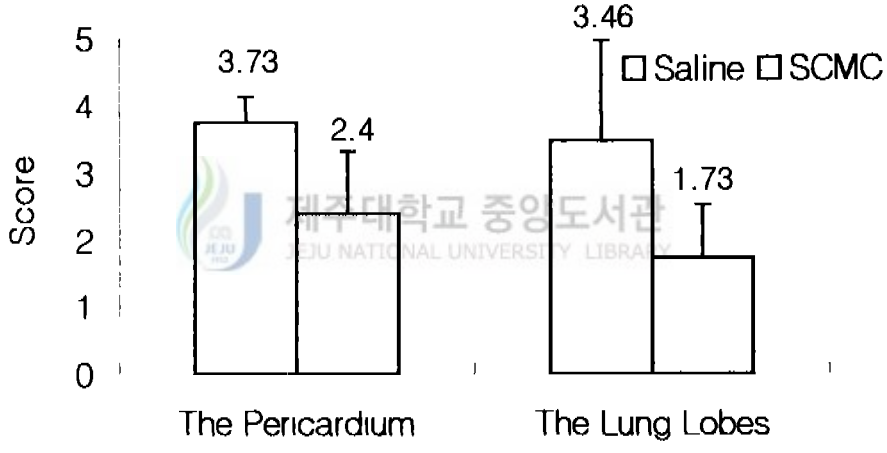

Figure 1. Mean adhesion scores of saline-treated group were significantly higher than that of SCMC-treated group in the pericardium and lung lobes ($p<0.01$).

2. Significant adhesion structures

There were no significant adhesion structures among the pleural structures (figure 2, 3). The mean score of the adhesions was 3.0 in the lung lobes, 3.0 in the heart and 3.2 in the sternum to the pericardium. Mean adhesion score in the lung lobes is shown in figure 3. Mean adhesion score was 2.8 in the pericardium, 2.7 in the parietal pleurum and 2.3 among the lung lobes. Therefore, there was no significant adhesion structure on the lung lobes. Also, there were no differences between saline-treated group and SCMC-treated group.

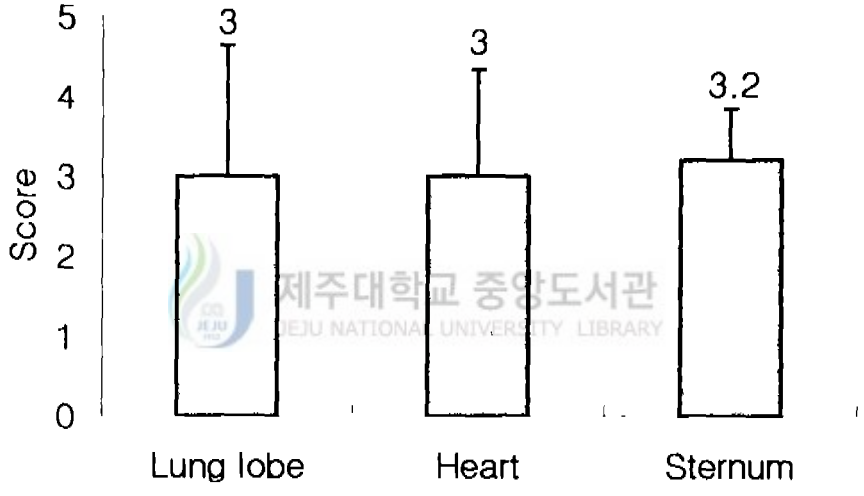

Figure 2. The mean adhesion scores of pleural structures on the pericardium. The mean adhesion score of the sternum was higher than other structures but significant differences among the structure were not found (Not significant at $p<0.05$).

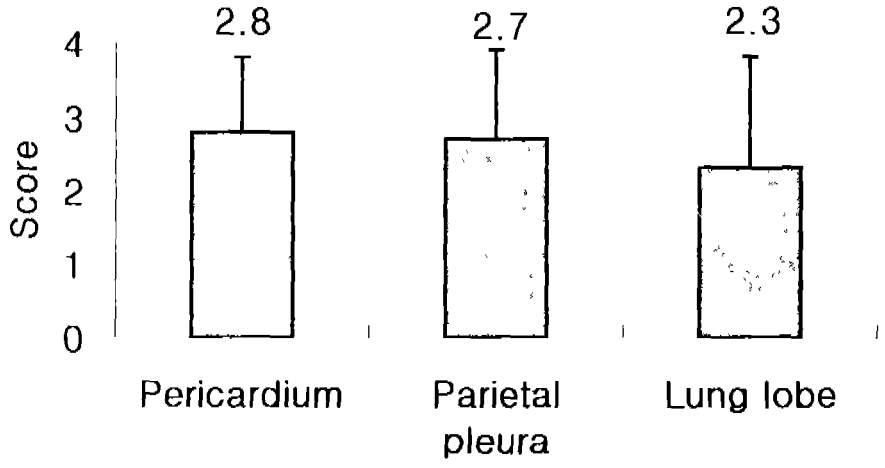

Figure 3. The pericardium was an adhesive structure on the lung lobe but there were no differences among the pleural structures significantly (Not significant at $p<0.05$).

3. Plasminogen concentrations

The plasminogen concentration in the control and SCMC-treated group is shown in the figure 4. Mean plasminogen concentration before the operation was 105.6% in saline-treated group and 105.9% in SCMC-treated group. On the first day after the operation mean plasminogen concentrations in saline-treated group and SCMC-treated group decreased to 28.2%, and 27.1% respectively. From the 4th day after the operation, mean plasminogen concentration in saline-treated group increased to 29.5% but it decreased further in SCMC-treated group (24.4%).

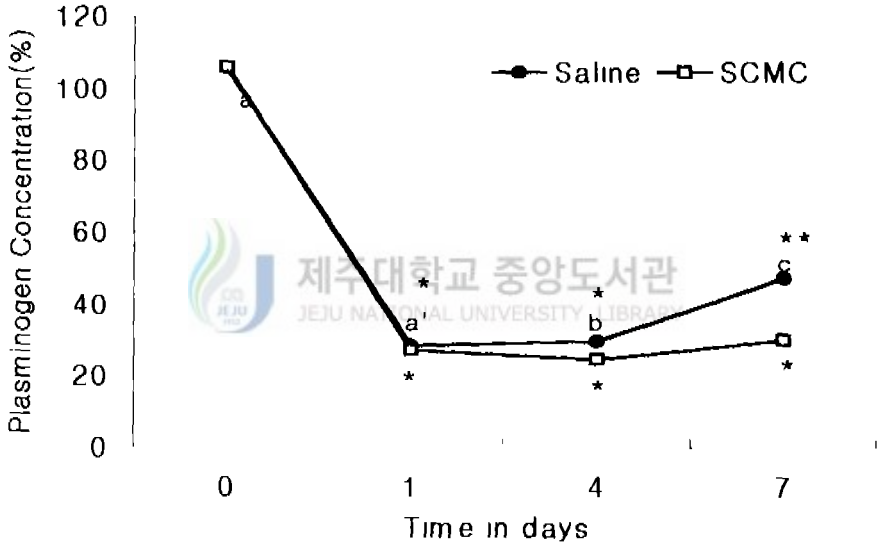

Figure 4. Mean plasminogen concentrations of saline-treated and SCMC-treated groups were similar at 3 days before the operation, but difference appeared from the first day after the operation. a:a', a:b, a:c; significantly differential pairs (*; $p<0.01$, **; $p<0.05$). There were no differences between saline-treated and SCMC-treated group.

4. Mean fibrinogen concentrations

Mean fibrinogen concentration in blood is shown in figure 5. Mean fibrinogen concentration in saline-treated group increased significantly to 580 ㎎/㎗ on the 1st day after the operation, but that of saline-treated group increased to 520 ㎎/㎗ on the 7th day after the operation in SCMC-treated group. Mean concentration of fibrinogen decreased on the 4th day after the operation and gradually decreased to 300 ㎎/㎗ in saline-treated group. Mean concentration of fibrinogen in SCMC-treated group increased slowly up to the 7th day and decreased on the 10th day after the operation.

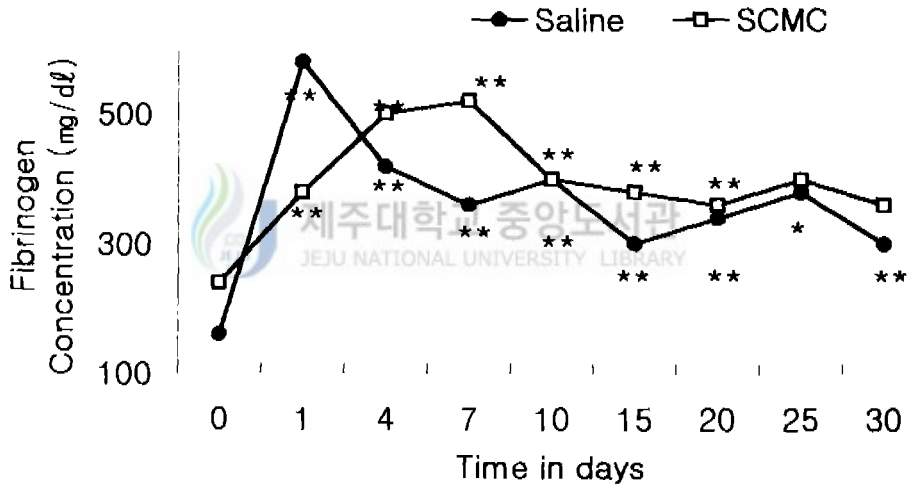

Figure 5. Mean fibrinogen concentration variation in saline-treated group significantly increased on the first day after the operation. In SCMC- treated group, the mean fibrinogen concentration peaked on the 7th day after the operation (*; $p<0.01$, **; $p<0.05$). There were any differences between saline-treated and SCMC-treated group.

5. WBC counts

Mean number of white blood cell (WBC) had no significant difference between saline-treated group and SCMC-treated group for 1 month (figure 6). Mean WBC counts of saline-treated group and SCMC-treated group were significantly increased on the 1st day and decreased gradually to the 7th day after the operation. In addition, mean WBC counts of SCMC-treated group were lower than saline-treated group.

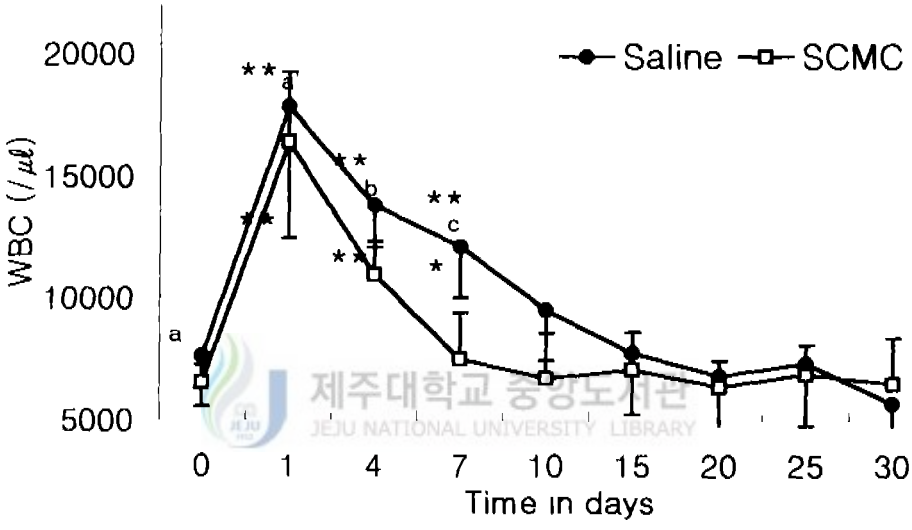

Figure 6. There was lower WBC value in SCMC-treated group than saline-treated group. *a*:*a'*, *a*:*b*, *a*:*c*; significantly differential pairs (*; $p<0.01$, ** $p;<0.05$). There were no significant differences between saline-treated and SCMC-treated group.

6. Lymphocyte and monocyte values

Mean values of the lymphocyte and monocyte counts are shown in figure 7 and figure 8. Mean value of the lymphocyte of SCMC-treated group was significantly increased on the 7th day after the operation (34.0%) but mean value of the lymphocyte of saline-treated group was not increased significantly. Mean value of the monocyte of saline-treated group (6.8%) and SCMC-treated group (9.6%) significantly increased on the 4th day after the operation. In addition, mean value of the monocyte of saline-treated group (15.8%) increased more on the 7th day after the operation and mean value of the monocyte of SCMC-treated group (9.8%) also increased. In saline-treated group, mean value of the monocyte increased to the peak point (15.8%) on the 7th day after the operation. The peak point of SCMC-treated group (9.8%) was achieved on the 10th day after the operation.

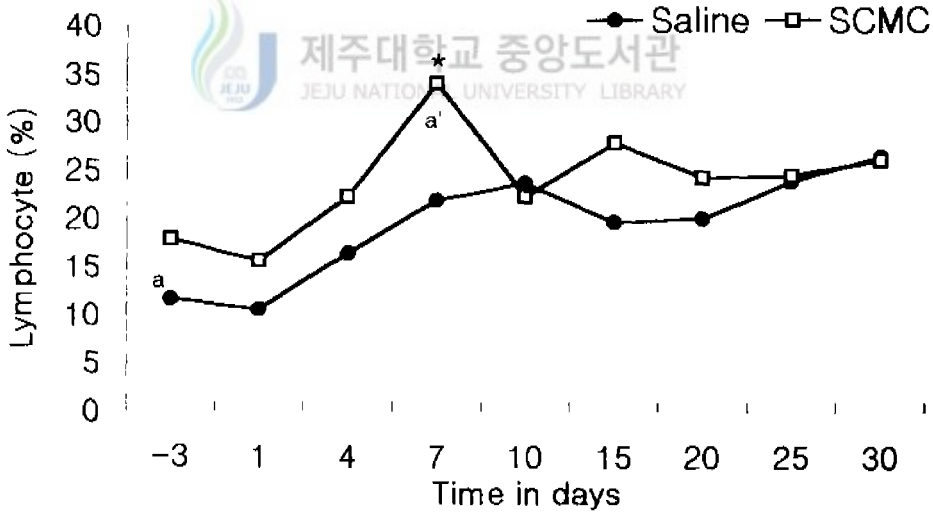

Figure 7. Mean value of lymphocyte count significantly increased on the 7th day after the operation in SCMC-treated group. a:a'; significantly differential pairs (*; $p<0.01$). There were no any significant differences between saline-treated and SCMC-treated group.

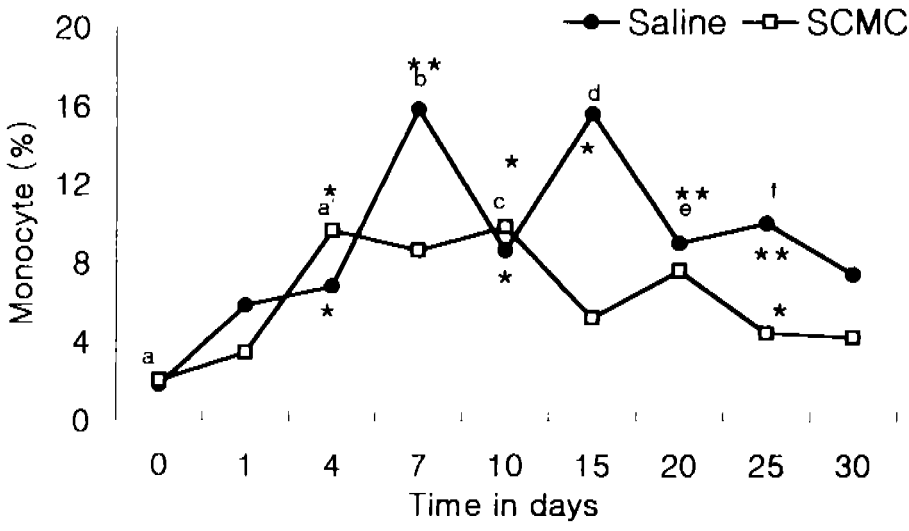

Figure 8. Mean monocyte count of saline-treated group was higher than that of the SCMC-treated group. The peak point of saline-treated group achieved on the 7th day but the peak point of SCMC-treated group was achieved on the 10th day after the operation. a:a, a:b, a:c, a:d, a:e, a:f; significantly differential pairs (*; $p<0.01$, **; $p<0.05$). There were no any differences significantly between saline-treated and SCMC-treated group.

7. RBC counts

Mean variation tendency of RBC count is shown in the figure 9. Mean RBC counts of saline-treated group ($4.4\times10^6/\mu\ell$) and SCMC-treated group ($5.1\times10^6/\mu\ell$) decreased after the operation. The RBC counts of SCMC-treated group decreased significantly on the 1st day after the operation and recovered slowly for one month.

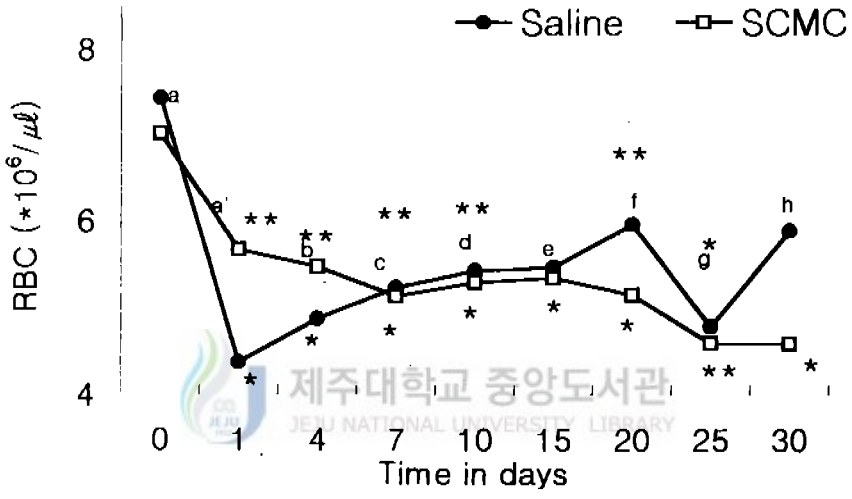

Figure 9. Mean RBC values in saline-treated group decreased on the 1st day after the operation and slowly increased during 30 days. Whereas, mean RBC values in SCMC-treated group slowly decreased during 30 days. a:a, a:b, a:c, a:d, a:e, a:f, a:g, a:h; significantly differential pairs (*; $p<0.01$, **; $p<0.05$). There were no any significant differences between saline-treated and SCMC-treated group.

8. PCV values

Mean packed cell volume (PCV) is shown in figure 10. PCV decreased on 1st day in control and SCMC-treated group and gradually increased for one month.

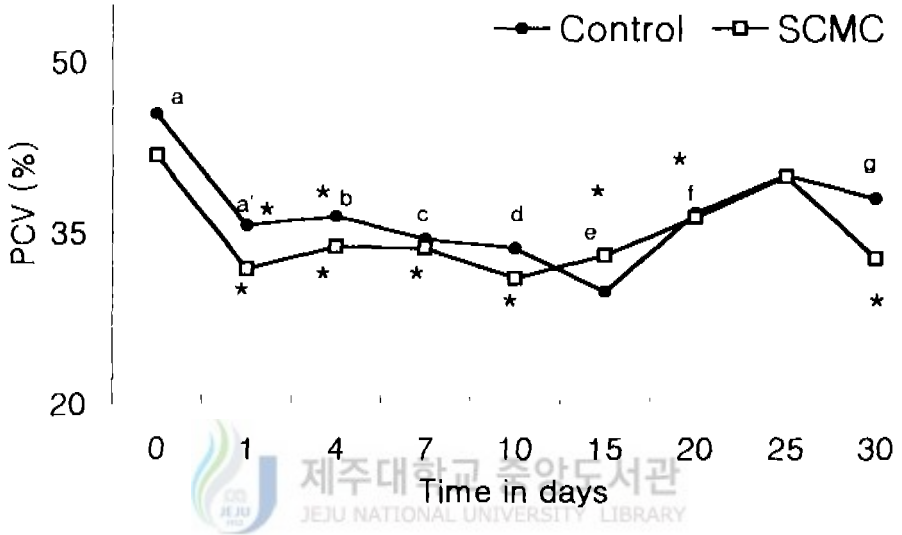

Figure 10. Mean packed cell volume variation decreased to 35.6% in saline-treated group and 31.8% in SCMC-treated group on the 1st day after the operation. a:a, a:b, a:c, a:d, a:e, a:f, a:g; significantly differential pairs (*; $p<0.01$, **; $p<0.05$). There were no differences between saline-treated and SCMC-treated group significantly.

Ⅳ. Discussion

Many of previous studies have suggested methods that can prevent postoperative adhesions as a complication of surgical treatment. Although intra-thoracic instillation of SCMC had good anti-adhesion effect, there were moderate to mild pleural or pericardial adhesions, however, in SCMC-treated group Although sufficient effort was made to avoid bleeding, two of animals in SCMC-treated group had accidental bleeding from the mediastinum and pericardium during the procedure. Therefore, to prevent unwanted bleeding, gentle manipulation of the soft tissue and immediate bleeding control is important to prevent adhesions. Previous studies by Poster *et al.* (1971) suggested that the fibrous framework for a mature fibrous adhesion might be provided not only by clotted exudate but also by clotted blood. Previous studies by Cliff *et al.* (1973) and Robinson (1987) demonstrated that autologous blood could induce pleurodesis in human recurrent pneumothorax patients. Exudate or blood clots can be eliminated from chest or pericardial areas by use of chest tube or intra-pericardial sump tubes, but the procedure may promote unexpected infection from hospital environment (Cunningham Jr. *et al.*, 1975).

Mean adhesion score of SCMC-treated group was lower than saline-treated group. Seeger *et al.* (1997) demonstrated that SCMC is six times as effective than saline, but there were not as dramatic event in this study. The increased adhesion scores in this study, compared with previous studies, may have been due to more vigorous and severe abrasions, which were inflicted in the animals, compared with those of the pervious studies. This experiment also suggested that intra-thoracic administration of 1% SCMC significantly reduce adhesion formation when compared with the saline-treated group. Although results of these trials have been varied, SCMC has substantially reduced the incidence of pericardial and pleural adhesions in dogs. Ryan and

Sax (1995) studied the efficacy and mechanism of action of the SCMC sponge, and they emphasized the primary importance of local physical barriers rather than more generalized effects mediated by soluble factors. The mechanism of SCMC have not been defined clearly, but it is suggested that separation of serosal surface because of its lubricating and "floating action". Normal saline is reabsorbed quickly and SCMC may leave more slowly. The fact may explain the positive result of this experiment.

Plasma plasminogen concentrations were at the lowest point on the first day after the operation but it increased slowly in saline-treated group. In the SCMC-treated group, plasminogen concentration did not increased compared with saline-treated group. Trent and Bailey (1986) demonstrated plasminogen variation after trauma. They suggested that activity of plasminogen activator initially decreases precipitously below base-line activity, then increase to well above base line values by 5 days after trauma, gradually decreasing to base-line values during the following weeks and months. In this experiment, plasminogen concentration decreased on the 1st day after the operation and increased a little on the 4th day after the operation. On the 7th day, mean plasminogen concentration increased more but there were differs between saline-treated group and SCMC-treated group. Mean plasminogen concentration of SCMC-treated group increased more slowly than saline-treated group. It may suggest that fibrinolytic activity be prolonged in SCMC-treated group. In addition, it may be explained that more acute and severe non-infectious inflammatory response presented in saline-treated group than SCMC-treated group. It also demonstrated that migration of plasminogen from tissue to blood was interrupted by SCMC in SCMC-treated group. More recent speculation by Ryan and Sax (1995) suggested that polymer coatings of SCMC prevent removal of plasminogen from traumatized surfaces, thereby increasing its availability for activation.

In saline-treated group, mean fibrinogen concentration was increased its peak point on the first day after the operation. The fibrinogen concentration

increased on the 7th day after the operation to peak point in SCMC-treated group. These results may suggest that fibrosis was disturbed and slowly formed in SCMC-treated group. Good *et al.* (1978) demonstrated that the fibrinogen concentration varied in a model of pleural adhesions. The peak fibrinogen concentration appeared 24 hours after the induction of adhesion and progressively decreased over time. In this experiment, mean fibrinogen concentration of saline-treated group reached the peak point on the 1st day after the experimental operation and decreased gradually for 30 days. The peak point of mean fibrinogen concentration in SCMC-treated group, however, was achieved on the 7th day after the operation. This might explained preventive efficacy of SCMC in pleural cavity.

Good *et al.* (1978) also suggested leukocyte values of pleural fluid. Pleural fluid WBC counts peaked at 24 hours and progressively decreased over 30 days. Mean WBC count of this study also demonstrates the variance of the leukocyte in pleural adhesion animal model. Mean WBC counts peaked on the 1st day after the operation in saline-treated group and decreased gradually. Although mean WBC counts of SCMC-treated group were much less than saline-treated group, similar variation tendency was observed.

Mean lymphocyte and monocyte counts were determined in this study. Activated macrophages and t-lymphocytes are known to they play an important role in postoperative wound healing and adhesion formation. Mean lymphocyte counts of saline-treated group were peaked on the 7th day after the operation but mean lymphocyte counts of SCMC-treated group peaked at 10th day after the operation. Leak *et al.* (1987) suggested that fibroblasts and macrophages increased but small number of lymphocytes were found on the 3rd day and fibroblast, macrophage and small numbers of lymphocyte were found at 8 days after adhesion induction. This study found that lymphocyte of blood increased on the 7th day and then decreased on the 15th day after the operation in pleural and pericardial adhesion animal model. Mean monocyte counts increased at 4th day after the operation. Rein and Hill (1989)

suggested that macrophage may further contribute to postoperative adhesion formation by stimulating angiogenesis and secreting plasminogen activators. Therefore, mean monocyte counts in this experiment re-demonstrate the suggestion of Rein and Hill (1989). Mean lymphocyte and monocyte counts of SCMC-treated group were lower than saline-treated group. Moreover, the changing tendency of SCMC-treated group was significantly different and slow variation tendency was observed. These results can explain the adhesion prevention effect of SCMC.

In order to accelerate diffusion of SCMC, the incised pericardium was left open. Usually the pericardium has been left open following the operation to permit drainage into the pleural spaces or mediastinum (Cunningham Jr. *et al.*, 1975). Moreover, additional reason was that attempt closure of the pericardium often visibly constricted the heart, with impairment of function. Previous study by Cunningham Jr. *et al.* (1975) and Nandi *et al.* (1976) suggested closure of pericardium after open-heart surgery. They demonstrated that closure of pericardium could reduce adhesion formation of the heart to the median sternum and cardiac tamponade. In this study, closure of pericardium was hazardous because it would inhibit diffusion of SCMC into the pericardial space. Moreover, if there were over-tension in pericardium, it might cause cardiac tamponade and fatal results. Malm *et al.* (1992) and Okuyama *et al.* (1998) suggested that cardiac tamponade occurs more often after pericardial closure. Pericardium adheres to the middle or caudal lung lobes most commonly in this study but there was no evidence of hypoventilation or exercise intolerance among the affected dogs. Except for pericardial adhesions to lung lobes, there were no additional adhesions in the thoracic cavity. Therefore, resection of the incised pericardium or closure of pericardium may be a sensible choice in surgical procedure. Kerstetter *et al.* (1997) reported the results of pericardiectomy in dogs. They suggested that the surgical procedure (subtotal vs. total pericardiectomy) was not significantly associated with survival time of dogs.

The dose of 1% SCMC in thoracic surgery was the main problem. In general abdominal and pelvic surgical procedures, 7 ㎖/㎏ of body weight of 1% SCMC have been used in veterinary surgical procedures until now but it may make artificial ascites (float action) which can interrupt normal movement of organs. The heart or the lung lobes are life-threatening organs. Seeger *et al.* (1997) experimented using SCMC to prevent postoperative pericardial adhesions. They used 25 ㎖ of 1% SCMC solution in weighing 15-20 kg dogs but in this study, the dose of 1% SCMC was a half of general abdominal or pelvic the operation (3.5 ㎖/㎏ of body weight) As a mechanism of SCMC, artificial pericardial effusion probably was induced. Previous studies by Good *et al.* (1978) and Ikäheimo *et al.* (1988) suggested that pericardial effusion can reduce cardiac tamponade and pleural fluid has not evident effect of adhesion formation. At necropsy, which was performed one month after experimental the operation, there wasn't any residual exudate or SCMC solution.

The information learned in this experiment has led to successful clinical application of SCMC for a canine heart worm (*Dirofilaria immitis*) removal operation by pulmonary ateriotomy in the canine patient. Blood contaminated pleural cavity was washed out by normal saline for several times and 1% SCMC was instilled into the pleural cavity during and after the operation procedure. Postoperatively the patient has done well without any clinical problem 5 months following the operation.

Ⅴ. Conclusions

The SCMC have been shown to be effective in the prevention of both pleural and pericardial adhesions. This study suggests that the dosage of 1% SCMC (3.5 ㎖/㎏ of body weight) could prevent postoperative pleural and pericardial adhesions without any complications. Furthermore, results of this study could reduce unexpected adhesions and bleeding in repeated intra-thoracic surgery.

Ⅵ. References

Beauchamp P. Z., Qiuigley M. M. and Held B.: Evaluation of progesterons for postoperative adhesion prevention. *Fertility and Sterility*, 1984, 538, 540-541.

Boggs D. S. and Kinasewitz G. T.; Review: Pathophysiology of the pleural space. *The American Journal of The Medical Sciences*, 1995, 309 (1). 53-57.

Cliff N. W. J., B. Phil C. D., Grob T. J. and Ryan G. B.: Postoperative pericardial adhesions. The role of mild serosal injury and spilled blood. *The Journal of Thoracic and Cardiovascular Surgery*, 1973, 65 (5), 744-749.

Cunningham J. N. Jr., Spencer F. C., Zeff R., Williams C. D., Cukingnan R. and Mullin M.: Influence of primary closure of the pericardium after open-heart surgery on the frequency of tamponade, postcardiotomy syndrome, and pulmonary complications. *The Journal of Thoracic and Cardiovascular Surgery*, 1975, 70 (1), 119-122.

Elkins T. E., Ling F. W., Ahokas R. A., Abdella T. N., Homsey C. A. and Malinak L. R.: Adhesion prevention by solutions of sodium carboxymethylcellulose in the rat Ⅰ, Ⅱ. *Fertility and Sterility*, 1984, 41 (6) 927-928, 930

Fredericks C. M., Kotry I., Holtz G., Askalaini A. H. and Serour G. I.: Adhesion prevention in the rabbit with sodium carboxymethylcellulose solutions. *American Journal of Obstetrics and Gynecology*, 1986, 155 (3), 667, 669-670.

Good J. T., Jr., Taryle D. A., Hyers T. M. and Sahn S. A.: Clotting and fibrinolytic activity of pleural fluid in a model of pleural adhesions. *American Review of Respiratory Disease*, 1978, 118, 903-905.

Hill-West J. L, Dunn R. C. and Hubbell F. A.: Local release of fibrinolytic agents for adhesion prevention. *Journal of Surgical Research*, 1995, 59, 759-761.

Ikäheimo M. J, Huikuri H. V., Airaksinen K. E. J, Korhonen U., Linnaluoto M. K., Tarkka M. R. and Takkuen J. T.: Pericardial effusion after cardiac surgery: Incidence, relation of the type of surgery, antithrombotic therapy, and early coronary bypass graft pateny. *American Heart Journal*, 1988, 116 (97), 97-101.

Kerstetter K. K., Krahwinkel D. J. Jr., Millis D. L. and Hahn K.: Pericardiectomy in dogs: 22 cases (1978-1994). *Journal of American Veterinary Medical Association*, 1997, 221 (6), 738.

Laks H., Hammond G. and Geha A. S.: Use of silicone rubber as a pericardial substitute to facilitate reoperation in cardiac surgery. *Journal of Thoracic and Cardiovascular Surgery*, 1981, 82, 90.

Leak L. V., Ferrans V. J., Cohen S. R., Eidbo E. E. and Jones M.: Animal model of acute pericarditis and its progression to pericardial fibrosis and adhesions: Ultrastructural studies. *The American Journal of Anatomy*, 1987, 180, 373-390.

Malm T., Bowald S., Bylock A. and Busch C.: Prevention of postoperative pericardial adhesions by closure of the pericardium with absorbable polymer patches: *An experimental study. The Journal of Thoracic and Cardiovascular Surgery*, 1992, 104, 600-601

Milgalter E., Uretzky G., Siberman S., Appelbaum Y., Shimon D. V., Kopolovic J., Cohen D., Jonas H., Appelbaum A. and Borman J. B.: Pericardial meshing; An effective method for prevention of pericardial adhesions and epicardial reaction after cardiac operations. *The Journal of Thoracic and Cardiovascular Surgery*, 1985, 90, 281-283.

Nandi P., Leung J. S. M. and Cheung K. L.; Closure of pericardium after open heart surgery. *A way to prevent postoperative cardiac tamponade. British Heart Journal*, 1976, 38, 1319-1321.

Okuyama N., Rodgers K. E., Wang C. Y., Girgis W., Oz M., St. Amand K., Pines E., DeCherney A. H., Rose E. A., Cohn D. and diZerega G. S.: Prevention of retrosternal adhesion formation in a rabbit model using bioresorbable films of polyethylene glycol and polyactic acid. *Journal of Surgical Research*, 1998, 78, 118-120.

Poster J. M, Ball A. P. and Silver D.: Mesothelial fibrinolysis. *Journal of Thoracic and Cardiovascular Surgery*, 1971, 62 (5), 726-728.

Rein M. S. and Hill J. A.: 32% dextran 70 (Hyskon®) inhibits lymphocyte and macrophage function in vitro: a potential new mechanism for adhesion prevention. *Fertility and Sterility*, 1989, 52 (6), 954-955.

Robinson R. J., Brown J. W., Deschner W. P., Highes B. and King H.: Prevention of pericardial adhesions with dextran 70. *The Annals of Thoracic Surgery*, 1984, 37 (6), 488-490.

Robinson C. L. N.: Autologous blood for pleurodesis in recurrent and chronic spontaneous pneumothorax. *The Canadian Journal of Surgery*, 1987, 30 (6), 428-429.

Ryan C. K. and Sax H. C.: Evaluation of a Carboxymethylcellulose sponge for prevention of postoperative adhesions. *The American Journal of Surgery*, 1995, 169, 154-157.

Seeger J. M. and Kaelin L. D., Staples E. M., Yaacobi Y., Bailey J. C., Normann S., Burns J. W., Goldberg E. P.: Prevention of postoperative pericardial adhesions using tissue-protective solutions. *Journal of Surgical Research*, 1997, 68, 63-66.

Strange C., Baumann M. H., Sahn S. A. and Idell S.: Effects of intrapleural heparin or urokinase on the extent of tetracycline-induced pleural disease, *American Journal of Critical Care Medicine*, 1995, 151, 509-512.

Trent A. M. and Bailey J. V.: Bovine peritoneum: Fibrinolytic activity and adhesion formation. *American Journal of Veterinary Research*, 1986, 47 (3), 653

Wiseman D. W., Kamp L., Linsky C. B., Jochen R. F., Pang R. H. L. and Scholz P. M.: Fibrinolytic drugs prevent pericardial adhesions in the rabbit. *Journal of Surgical Research*, 1992, 53, 362-366.

Xie C., Teixeira L. R., McGovern J. P. and Light R. W.: Systemic corticosteroids decrease the effectiveness of talc pleurodesis. *American Journal of Respiratory and Critical Care Medicine*, 1998, 157, 1441-1442.

Youmans C. R. Jr., White J. and Derrick J. R.: The prevention of pleural and pericardial adhesions with silastic. *Journal of Thoracic and Cardiovascular Surgery*, 1968, 55 (3), 383-387.

초록

개에서 Sodium Carboxymethylcellulose의 흉막 및 심낭에 대한 유착방지효과

(지도교수: 정 종 태)

정 동 규

제주대학교 대학원

수의학과

개와 사람의 흉강수술 또는 개심수술 시에 발생하는 흉막과 심낭의 유착은 합병증을 발생시킨다. 이러한 흉강유착의 방지를 위해 1% sodium carboxymethylcellulose (SCMC)를 개의 흉막 및 심낭에 적용하였다.

10두의 개를 SCMC 투여 군과 생리식염수 투여 군으로 각각 5두씩 나누었다. 실험 개의 흉강 내로 접근 후 4번째에서 6번째 늑간에 건조된 거즈를 사용하여 찰과상을 유도하였고 심낭을 절개하고 절개면의 양측에 2 ㎝ × 2 ㎝ 크기로 심외막과 심낭 사이에 찰과상을 유도하였다. 인위적인 찰과상의 유도 후, 생리식염수 투여 군에서는 멸균 생리식염수를 체중 kg당 3.5 ㎖의 용량으로 흉강 및 심낭 내로 도포하였고 SCMC 투여 군은 1% SCMC를 같은 용량으로 흉강 내와 심낭 내에 도포하였다. 수술 전과 후에 CBC와 혈장 plasminogen 치를 측정하였다. 유착의 정도는 수술 30일 후에 0-4로 점수화 하여 판정하였다. SCMC 투여 군에서의 심낭의 평균 유착치는 2.4±0.8, 생리식염수 투여 군에서의 심낭과 심장과의 평균 유착치는 3.7±0.9로 나타나 SCMC 투여 군에서 유의성 있게 낮았다($p<0.01$). 폐엽과 흉막간의 평균 유착치는 SCMC 투여 군에서는 1.7±0.2로 나타나서 saline 투여 군의 평균 유착치 3.5±0.8 보다 현저히 낮았다($p<0.01$). saline 투여 군의 혈중

plasminogen 농도는 술 후 1 일에 28.2±5.6%로 감소하였고, 술 후 7 일에 47±41.4%로 증가하였다($p<0.05$). SCMC 투여 군에서는 실험적 수술 1 일 후 27.1±10.3%로 감소하다가 7 일 후에는 30.8±21.6%로 증가하였다($p<0.01$).

흉강 및 개심 수술 중 1% SCMC 를 투여하여 흉강 내의 유착을 방지함으로써 재수술이 필요한 경우에 수술의 어려움과 조직손상의 위험을 감소시킬 수 있다.

중심어: 개, 흉막, 심낭, 유착방지, SCMC