啓明醫大論文集 第5卷 第2號
The Keimyung Univ. Med. J.
Vol. 5, No. 2, December 1986

An Experimental Study of Postoperative Intraabdominal Adhesions*

Joong Shin Kang, MD, FACS; Dong-Whi Yang, MD; Soo Sang Sohn, MD; In Ho Kim, MD; Bong Woo Lee, MD; Bong Rak Choi, MD

Department of Surgery, Keimyung University School of Medicine, Taegu, Korea

=국문 초록=

술후 장유착에 대한 실험적 연구

계명대학교 의과대학 외과학교실

강중신 · 양동휘 · 손수상 · 김인호 · 이봉우 · 최봉락

수술후 나타나는 장유착은 적지않은 빈도를 나타내며 보편화된 개복 수술후 증가된 유착성 장폐색증은 외과영역에서 중요한 문제의 하나로 많은 연구보고가 되고 있으며 유착의 형성은 기계적, 세균학적 및 화학적 외상 즉 복강내 외상이나 손상후의 치유과정의 한단계로 유착이 나타난다고 한다. 장유착의 원인과 이차적인 병태생리학적인 변화에 대한 충분한 이해를 갖고 조기에 적절한 치료를 하면 이병율과 사망율을 감소시킬 수 있는 질환이다. 저자들은 한국산 성숙된 가토를 이용하여 실시한 실험적 연구로써 토끼 60마리를 각 20마리씩 3군으로 나누어 관찰하였다. 즉 모든 토끼는 ether로 open drip마취를 하고 정중선 복벽절개로 개복한 후 5.0×5.0cm 정도의 전벽복막을 겸상 출혈이 나타날 때 까지 찰과상을 형성시켜 그 결과를 관찰하였다. 제1군의 20마리는 단지 scratching method만 시행한 control group으로 하고 제2군의 20마리에서는 scratching method 후 복강내 polyethylene feeding tube를 넣고 매일 50cc의 생리식염수를 주입하였으며 제3군 20마리에서는 복강투석액인 peritosol solution으로 생리식염수 대신에 매일 50cc씩 복강내에 주입하여 관찰 비교하였다.

모든 토끼들은 개복술 10일후 재 개복하여 복막의 유착과 소장간의 유착정도를 관찰비교하여 다음과 같은 결과를 얻었기에 문헌고찰과 함께 보고하는 바이다. Control group에서는 20예중 유착정도가 15예에서 나타나 75%를 나타내었고 생리식염수 투여군에서는 20예중 13예에서 나타나 65%의 유착을 나타내었으며 peritosol 군에서는 20예중 9예로서 45%로 감소된 유착양상을 나타내었다. 본 실험에서는 peritosol투여군이 control group이나 생리식염수 투여군보다 실험적 유착상태가 적은것에 유의를 하였으며 아직 인체에 peritosol제적 시도는 못해 보았지만, 본실험과 같은 효과가 있다면 술후 장유착 예방에 의의가 있을 것으로 사료되어 보고 드리는 바이다.

Introduction

The formation of adhesions represents a phase in the dynamic healing process as the reaction to the peritoneal injury. Intraabdominal adhesions are almost inevitable following major abdominal surgery.

Trauma, whether mechanical, bacterial or chemical, appears to be the etiologic factor in

* 본 논문은 1985년도 계명대학교 동산의료원 특수과제 연구비로 이루어졌음.

the production of adhesions. The extent of intraperitoneal reactions appears to reflect the degree of damage inflicted.

Many agents have been studied experimentally with possible usefulness in preventing the formation of intraperitoneal adhesions[1,2].

This experimental study was undertaken in order to observe the formation of intraperitoneal adhesions in the rabbits by using saline and peritosol solution which is used in the patients with chronic renal failures.

Materials and Methods

Korean adult rabbits weighing 2 to 3 kg were used. They were anesthetized by the open drip method with ether and nembutal injection intravenously. The abdomen was prepared with betadine solution after shaving of abdominal hairs. The abdomen opened with the midline incision about 9cm in length under clean, aseptic technic. Each edge of the wound was elevated and the adjascent peritoneal surface, 5.0×5.0cm in size, was thoroughly abraded by scratching method with a back of knife until petechial hemorrhages were visible. The peritoneum and fascia were closed carefully with everting mattress suture of 3-0 chromic catgut and the skin was closed with No.3 silk continuous sutures.

Animals in group Ⅰ had their abdominal cavity closed with only scratching method (control group). And group Ⅱ was treated with continued saline irrigatiotn with a feeding polyethylene tube in the peritoneal cavity (saline group), 50ml/day for 10 days. The group Ⅲ was treated with continued Peritosol 250 solution irrigation with a feeding tube in the peritoneal cavity (peritosol group), 50ml/day for 10 days. Each group consists of 20 rabbits serving as models. The peritosol solution is used for the patients with chronic renal failure as a peritoneal dialysis solution material. All animals were opened on the tenth day and the number and density of adhesions were noted and recorded.

Results

The results are recorded in the table 1 and 2.

We classified the adhesions into 4 groups: clean, minimal, moderate and severe. Clean group means no formation of adhesions. Minimal group means formation of a few thin fibrous bands between the loops or peritoneal wall and only a slight granulation on the scratched site. Moderate group represents of the formation of multiple thin fibrous bands between the loops and to the peritoneal walls.

Severe group represents of the formation of thick fibrous bands or firm adhesions between the loops and to the peritoneal walls.

Clinically, the clean and minimal groups have no significant problems, because there are only fibrinous adhesions and the fibrin can be reabsorbed in the near future.

But the fibrous adhesions may be formed by the ingrowth of fibroblast and they also can be absorbed or become organized into persistent, and potentially dangerous fibrous strands.

In the experimental animal study, adhesions were noted in 75% of the control group and 65% of the saline treated group respectively.

But in peritosol group, we found adhesions

Table 1. Influence of peritosol solution and saline on the formation of intra-abdominal adhesions following experimenal trauma

	Clean	Minimal	Moderate	Severe	No. with Adhesions
Control group	2	3	2	13	15
Saline group	2	5	5	8	13
Peritosol group	6	5	5	4	9

Table 2. Summary of Groups treated for 10 days following operation

	No. of Animals	No. with adhesions	Percent with adhesions
Control	20	15	75%
Saline	20	13	65%
Peritosol	20	9	45%

in only 45% of the animals.

It was clear that those treated with peritosol had a decreased incidence of peritoneal adhesions.

In general, when adhesions occurred in peritosol treated rabbits, they were relatively few and delicate, and they were involved around the abdominal wall suture line.

In contrast, adhesions in control animals tended to be more dense and more numerous, and adhesions in saline group tended to be somewhat dense and more numerous than peritosol group, but they were less prominent than control group in the nature of severity.

Discussions

In the era before abdominal surgical procedures had become an everyday occurrence, in traabdominal adhesions were of little importance. Strangulated hernias accounted for a high percentage of the total instance of intestinal obstruction while obstruction due to adhesions was comparatively uncommon.

In the extensive review of intestinal obstruction, Vick observed, even as late as the 1920's, that adhesions accounted for only 7% of the admissions compared with 49% due to strangulated hernias[3].

The study by McIver showed 44% were due to strangulated hernias and 30% due to band and adhesions[4]. McAdam noted a 75% incidence of strangulated hernias compared with only 4% incidence of adhesions in his large series of 794 patients with obstructions[5].

Today, in so called civilized communities, adhesions are becoming more and more common as a cause of obstruction with hernias becoming less and less prominent. Wangensteen noted only 10% incidence of strangulated hernias compared with 37% due to adhesions in 1252 instances for 12 years duration[6].

As more and more abdominal operations are performed, postoperative adhesions develop more frequently in patients, and the potential risks of intestinal obstruction becomes greater; at the same time, more and more patients have hernias repaired electively and therefore are in little danger of subsequent strangulation.[7]

By far the most common cause of intra-abdominal adhesions is previous surgical treatment. Becker observed that in 412 patients the previous operations accounted for 90% of obstructions caused by adhesions[8].

The causes of postoperative adhesions were described by many authors. Baillie[9], Cruveilhier[10], Rockitanski[11], Paget[12] and Treves[13] described the temporary fibrinous adhesions of coagulated lymph in acute peritonitis and persistent fibrous adhesions which may develop subsequently. Baillie mentioned that he could demonstrate by injection studies that there were delicate blood vessels in these permanent adhesions[9].

From numerous observations, surgeons became familiar with early fibrinous adhesions which stuck loops of intestine and other abdominal viscera to one another within a few hours of operation, inflammation, or trauma[14].

Such fibrinous material either may be reabsorbed completely or may become organized with ingrowth of capillaries and fibroblasts into established fibrous adhesions[2,7,14]. And studies show that damages of the peritoneal endothelium, rough handling, retraction, surgical denudation and so on will necessarily

be followed by the formation of fibrous adhesions[14].

Buckman et al have shown that peritoneal defects have a high plasminogen activity measured by the area of lysis produced on fibrin plates. This activity is lost in peritoneum which has been rendered ischemic by grafting or by tight suturing and moreover such ischemic tissue may actively inhibit fibrinolysis by normal tissue[15]. This phenomenon also explains the failure of intact peritoneum to lyse fibrinous adhesions to adjacent ischemic tissue.

Also some substances may cause formation of granulation and development of fibrous intraabdominal adhesions, they were well studied by Myllarniemi[17] and his study showed foreign body reactions by talc, thread and starch, extruded gut contents sutures or a mixture of materials[17].

Capperauld has shown that autoclaved starch is absorbed from the peritoneal cavity in about 48 hours where irradiated starch persists for 70 days longer and produces much greater incidence of adhesion formation in the experimental animals[18]. The attempts to prevent adhesions have been approached from a number of different aspects, which can be classified as follows[19~21].

(1) Prevention of fibrin deposition in the postoperative peritoneal exudate.

This has involved the use of anticoagulants such as citrate, heparin, dicoumarol, Dextran and aprotinin (Trasylol) as a possible antiplasmin agents.

(2) Removal of fibrin exudate by means of intraperitoneal lavage, enzymes such as pepsin, trypsin and papain, and fibrinolytic agents such as streptokinase, actase and urokinase.

(3) Separation of surfaces has been advised by such methods as distention of the abdominal cavity with oxygen, stimulation of peristalsis with prostigmine to prevent prolonged contact between adjacent loops of intestine and the use of such substances as a olive oil, liquid paraffin, amniotic fluid, membranes of fish bladder, ox peritoneum, amniotic membrane, oiled silk, silver or gold foil, free graft of omentum and silicones to separate damaged loops of bowel.

(4) Inhibition of fibroblastic proliferation has included the use of antihistamines, steroid and cytotoxic drugs.

The treatment and prophylaxis of the adhesions were studied with numerous methods. Unnecessary adhesion formation can be reduced by meticulous surgical technique, and this must include the prevention of granuloma formation from foreign materials such as gauze, glove powder or long redundant ends of non-absorbable sutures[14].

The omentum should be drawn over the abdominal organs before closing the abdomen and it should be wrapped over any anastomotic line.

A number of plication procedure have been advocated which are designed to avoid acute kinks of the matted bowel. The operation was first reported by Finnish surgeon, Wickmann in 1934, but was popularized by Nobble[22,23]. More recently, transmesenteric plication of loops of small intestine in a serpentine pattern has been advocated as a simpler and safer procedure by Childs and others[24].

Nowadays a new technique for mesenteric catheter plication for recurrent advanced obstruction of the small intestine was introduced by Mexican surgeon, Vazguez in 1985[37]. It is actually a modification of Nobble plication and this technique is a simple, safe and effective method.

In 1959, Baker described an ingenious technique of threading a tube down the whole lenth of the small intestine via jejunostomy which, by its intrinsic stiffness, would prevent kinking while adhesions develop.

The contents of peritosol solution in our experimental study is described in Table 3.

Peridural, spinal or lumbar anesthesia and section or pharmacological blockade of sympathetic nerves have also been reported to reverse or prevent development of gastrointes-

Table 3. The electrolyte concentrotion of peritosol solution/liter

Contents	Peritosol 150	Peritosol 250	Peritosol 425
Dextrose	13.640g/l	22.708g/l	38.650g/l
Sodium	132mEq/l	132mEq/l	132mEq/l
Calcium	3.5mEq/l	3.5mEq/l	3.5mEq/l
Magnesium	1.5mEq/l	0.5mEq/l	1.5mEq/l
Chloride	102mEq/l	96mEq/l	102mEq/l
Lactate	35mEq/l	40mEq/l	35mEq/l
Total osmolarity	347mOsm/l	396mOsm/l	486mOsm/l
Approx PH	5.5	5.5	5.5

tinal ileus[27~31].

In the historical aspect, in 1912 Hartwell and Houget reported that they had a good result from an experimental intestinal obstruction in dogs by large amount of normal saline solution irrigation[32].

In 1932, Wangensteen reported successful decompression of 3 cases of mechanical bowel obstruction by nasal catheter suction siphonage [33~35].

Evidence of suppressed formation of peritoneal adhesions due to talcum powder by cortisone was first reported by Scheinberg and Saltzstein [36,38,39].

Similar findings have been reported by Hubay and Weckesser using dogs[40].

They reported that cortisone did not completely prevent adhesions in any animal, though the adhesions were, in general, less extensive and less dense[40].

In 1967, Aboulafia and Polishuk reported the prevention of peritoneal adhesions by silicone solution using rabbits[41].

They made serosal injury by rubbing method to the rabbit small bowel.

The degree of adhesion formation resulting from the operative procedure was evaluated according to the classification of Knigbtly et al[42].

They classified into 5 grades, the result was somewhat similar to ours and they concluded that silicone served as an effective means for the mechanical separation of injured peritoneal areas and in so doing prevents adhesion formations.

Summary

authors observed that there were almost none or minimum evidence of any adhesion formations among the patients treated by peritoneal dialysis with peritosol solution and those with chronic ascites.

authors divided rabbits into 3 groups and group Ⅰ had no other treatment except laparotomy and closure of abdomen. Group Ⅱ had saline irrigation and group Ⅲ peritosol solution irrigation, each for 10 days following surgery.

The present study showed that group with peritosol irrigation had more favorable results in diminishing experimentally produced adhesions than saline or control groups.

If this has a similar effect in human patients, it should be worthwhile to try as one of the useful method for the prevention of the postoperative adhesions.

References

1. Jacomain RJ, Shumacker HB: Effect of Histadyl Upon the Prevention of Peritoneal Adhesions. *Am J Surg* 1962 : 104 : 20—21.
2. Jackson BB: Observations on Intraperitoneal Adhesions-An Experimental Study. *Surgery* 1958 : 44 : 507—514.
3. Vick RM: Statistics of acute intestinal obstruction. *Br Med J* 1932 : 2 : 546.

4. McIver MA: Acute intestinal obstruction: General considerations. *Arch Surg* 1932 : 25 : 1098.
5. McAdam IWJA: 3-year review of intestinal obstruction, Mulago Hospital, Kampala, Uganda. *East Afr Med J* 1961 : 38 : 536.
6. Wangensteen OH: *Intestinal Obstruction*, ed 3. Springfield Charles Co. Thomas Publisher, 1955.
7. Ellis H: The cause and prevention of post operative intraperitoneal adhesion. *Surg Gynecol Obstet* 1971 : 133 : 497.
8. Becker WF: Acute adhesive ileus; a study of 412 cases with particular reference to the abuse of tube decompression in treatment. *Surg Gynecol Obstet* 1952 : 95 : 472.
9. Baille M: *The Morbid Anatomy of the Human Body*, London, 1833.
10. Cruveilhier J Traite: *d'anatomie pathologique generale*, Paris, 1849.
11. Rokitansky CA: *Manual of Pathological Anatomy*, Vol II. London, Sydenham Society, 1849.
12. Pacet J: *Lectures on Surgical Pathology*, ed 3. London, Longman, 1870.
13. Treves F: Intestinal obstruction; its varieties, with their pathology, diagnosis and treatment. London, Cassell & Co Ltd, 1888.
14. Ellis H: The cause and prevention of intestinal adhesions. *Br J Surg* 1982 : 69 : 241—243.
15. Buckman RF, Woods M, Sargent L, et al: A unifying pathogenetic mechanism in the etiology of intraperitoneal adhesions. *J Surg Res* 1976 : 20 : 1—5.
16. Buckman RF, Buckman PD, Hufnagel HV, et al: A physiologic basis for the adhesion-free healing of deperitonealized surfaces. *J Surg Res* 1976 : 21 : 67—76.
17. Myllarniemi H: Foreign material in adhesion formation after abdominal surgery. *Acta Chir Scand* 1967 : (Suppl) : 377.
18. Capperauld I : Influence of sterillisation methods on the incidence of glove starch granuloma. *Eur Surg Res* 1977 : 9(Suppl 1) : 70.
19. Boys F: The prophylaxis of peritoneal adhesions: A review of the literature. *Surgery* 1942 : 11 : 118—68.
20. Connolly JE, Smith JW: The prevention and treatment of intestinal adhesions. *Surg Gynecol Obstet* 1960 : 110 : 417—31.
21. Ellis H: The cause and prevention of post-operative intraperitoneal adhesions. *Surg Gynecol Obstet* 1971 : 133 : 497—511.
22. Noble TB: Plication of small intestine as prophylaxis against adhesions. *Am J Surg* 1937 : 35 : 41—4.
22. Sivula A, Asp K: Wichmann's plication in the treatment of recurrent intestinal obstruction due to adhesions. *Acta Chir Scand* 1966 : 131 : 99—106.
24. Childs WA, Phillips RR: Experience with intestinal plication and a proposed modification. *Ann Surg* 1960 : 152 : 258—65.
25. Ferguson AT, Reihmer VA, Gaspar MR: Transmesenteric plication for small intestinol obstruction. *Am J Surg* 1967 : 114 : 203—8.
26. Baker JW: A long jejunostomy tube for decompressing intestinal obstruction. *Surg Gynecol Obstet* 1959 : 109 : 518—20.
27. Dubois A, Weise VK, kopin IJ: Postoperative Ileus in the Rat. *Ann Surg* 1972 : 178 : 781—786.
28. Catchpole BN: Ileus: Use of sympathetic Blocking Agents in its Treatment. *Surgery* 1969 : 66 : 811.
29. Devin J: A Concept of Paralytic Ileus: A Clinical Study. *Br J Surg* 1946—1947 : 34 : 158.
30. Cius JA, Peterson CG: Postoperative Ileus and Related Gastrointestinal Complications. *Int Abstr Surg* 1944 : 79 : 265.
31. Petri G, Szenohradszky J, Porszasz-Gibiszer K: Sympatholytic Treatment of "Paralytic" Ileus. *Surgery* 1971 : 70 : 359.
32. Hartwell JA, Hoguet JP: Experimental intestinal obstruction in dogs with special reference to the cause of death and the

treatment by large amount of normal saline solution. *JAMA* 1912 ; 59 : 82.

33. Sabiston DC: ***Textbook of surgery***, ed 13. Philadelphia, WB Saunders, 1986, p 997.
34. Schwarz SI: ***Principles of surgery***, ed 4. McGraw-Hill Company, 1984, pp 1034—1152.
35. Wangensteen OH: Early diagnosis of intestinl obstruction with comments of pathology and treatment with report of sucessful decompresion of 3 cases of mechanical Bowel obstruction by nasal catheter suction siphonage. ***West J Surg*** 1932 ; 40 : 1.
36. Han JW, Youn TY: A Clinical Study of Intestinal Obstruction in Adult. *JKSS* 1986 ; 31 : 453—454.
37. Vazguez MT, Jalisco G, Speare OR: A New Technique for Mesenteric Catheter Plication for Recurrent Advanced Obstructon of the Small Intestine. ***Surg Gynecol Obstet*** 1985 ; 161 : 289—291.
38. Scheinbery SR, Saltzstein HC: Effect of cortisone and ACTH on intra-abdominal adhesions. ***Arch Surg*** 1951 ; 63 : 413—420.
39. Scheinberg SR, Saltzstein HC, Johnson AS: The prevention of adhesions in the chest and the pericardium by cortisone. Surgical Forum, American College of Surgeons, Philadephia, WB Saunders Co, 1951.
40. Hubay CA, Weckesser EC, Holden WD: The effect of Cortisone on the Prevention of Peritoneal Adhesions. ***Surg Gyncol Obstet*** 1953 ; 96 : 65—70.
41. Aboulafia Y, Polishuk WZ: Prevention of Peritoneal Adhesions by Silicone Solution. ***Arch Surg*** 1967 ; 94 : 384—387.
42. Knightiy JJ, Agostino D, Clifton EE; The Effect of Fibrinolysin and Heparin on the Formation of Peritoneal Adhesions. ***Surgery*** 1962 ; 52 : 250.