EXPERIMENTAL STUDY

Preventive effect of fucoxanthin administration on intra-abdominal adhesion: An experimental animal study

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ABSTRACT

BACKGROUND: The most common cause of intra-abdominal adhesion (IAA) is previous abdominal surgery and mortality. IAA can cause serious complications such as chronic abdominal pain, ileus, and infertility. Approximately 3% of all laparotomies are related to adhesions. IAA reduces the quality of life of the patient, causes morbidity, and increases health expenditures. In this study, we aimed to investigate the preventive effect of fucoxanthin (Fx) on IAA in the intra-abdominal surgical adhesion model that experimentally created in rats.

METHODS: This study used 21 Sprague-Dawley rats divided into three groups. After anesthesia, the abdomen was opened, the cecum and right abdominal wall were damaged with a sterile toothbrush until petechiae bleeding was seen. No additional action was taken to the control group. In the sham group, 5 cc saline solution was released into the peritoneum before the abdomen was closed. In the Fx group, 35 mg/kg Fx was instilled intraperitoneally and the abdomen was closed. On the 21st post-operative day, all subjects were anesthetized with standard anesthesia. Macroscopic adhesions were quantitatively evaluated according to the Mazuji classification. The cecum anterior wall and parietal peritoneum were excised for pathological sampling. A pathologist, unaware of the groups, evaluated inflammation, fibroblastic activity, and vascular proliferation. In addition, serum tumor necrosis factor-alpha (TNF-α) and interleukin-10 levels were measured.

RESULTS: No rat was lost during the study period. Congenital adhesion was not observed in any of the subjects at the first laparotomy. Adhesion was significantly less macroscopically in the Fx group compared to the control and sham group ($p<0.001$ and $p<0.001$). Fibroblastic activity was found to be significantly less in the Fx group compared to the sham and control groups ($p<0.001$ and $p<0.001$). Vascular proliferation was found to be significantly less in the Fx group than in the sham and control groups ($p<0.001$ and $p<0.001$). The inflammation score was significantly lower in the Fx group compared to the other two groups ($p<0.001$ and $p<0.001$). The inflammation score in the sham group was lower than the control group and was statistically significant ($p<0.001$). TNF-α level was found to be statistically significantly lower in the Fx group compared to the sham and control groups ($p<0.001$ and $p<0.001$).

CONCLUSION: As a result of experimental study, we can say that Fx is effective in preventing IAAs and decreases the level of TNF-α, a pro-inflammatory cytokine.

Keywords: Adhesion; intra-abdominal adhesion; fucoxanthin; pro-inflammatory cytokine.

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INTRODUCTION

Intra-abdominal adhesion (IAA) occurs as a result of damage to the mesothelial layer due to causes such as trauma, ischemia, inflammation, and infection in the peritoneal cavity, causing builders between damaged tissues and other tissues to repair the fibrin plexus on the surface. Fibrin is broken down by fibrinolytic enzymes such as plasmin in a healthy intra-abdominal cavity. However, as these fibrinolytic enzymes become inactive in the presence of inflammation, fibrin deposits and protein-rich fibroblasts proliferate locally and cause permanent adhesions.[1,2] The most common cause of IAA is previous abdominal surgery. Although almost all patients who undergo intra-abdominal surgery develop adhesions, the level of these adhesions, time, and severity of symptoms are highly variable. It can cause serious complications such as chronic abdominal pain, ileus, and infertility. Post-operative adhesions are the primary cause of small bowel obstruction and constitute 70% of admissions for intestinal obstruction. Approximately 3% of all laparotomies are related to adhesions.[3] Today, when the literature on the studies to prevent adhesion development is reviewed, it is seen that substances preventing proliferation, inflammation, and fibrin production and chemotherapeutic drugs are used in addition to solid, gel, and solution barriers.[4,5] However, an effective method or drug has not yet been found. IAA continues to be a health problem that needs to be solved today, as it reduces the quality of life of the patient, causes morbidity and mortality, and increases health expenditures.[6]

Fucoxanthin (Fx) is a member of the carotenoid family, a brown-orange pigment found in brown algae. Since the marine environment is completely different from the terrestrial environment, many marine organisms produce active substances with specific functions and Fx, one of the special structures, is an antibacterial, antiviral, antitumor, anti-inflammatory, protective, antioxidant, and anticoagulant agent.[7,8] In this study, it was aimed to investigate the preventive effect of Fx on IAA in the intra-abdominal surgical adhesion model that experimentally created in rats.

MATERIALS AND METHODS

This experimental study was conducted by T.C Dicle University Prof. Dr. Sabahattin Payzın Health Sciences Research and Application Center Experimental Animals Local Ethics Committee (DUHADEK) was held in DUHADEK laboratory by obtaining the ethics committee approval dated June 03, 2020 and protocol number 2020/22.

A total of 21 female/male Sprague-Dawley rats, each 200–250 g, were used in the study. All groups were followed in separate cages with no food, water, and movement restrictions, at 20–22°C, 50–60% relative humidity, and 12 h day-night cycles. Three different groups were formed as the control, sham, and FK groups, each with seven rats. Fx used in the study was 95% pure (Sigma®). The rats were fasted for 12 h before surgery and only allowed to drink water. Operations were performed under sterile conditions and anesthesia. For anesthesia, 50 mg/kg ketamine hydrochloride (Ketalar®, Pfizer, Istanbul) and 1 ml/kg xylazine hydrochloride (Rompun®, Bayer, Istanbul) were administered intramuscularly. After anesthesia, the rats were placed in the dorsal reclining position and the anterior abdominal wall was shaved. Then, 10% povidone iodine (Isosol®, Central Lab, Ilac San, Turkey) was provided with antisepsis. A 4 cm midline incision was made to apply the adhesion model. After it was determined that there was no adhesion in the abdomen, the cecum was exposed. Then, with a sterile toothbrush, damage was created in the cecum until petechial bleeding areas were seen, and this area was sutured with 5/0 Vicryl to increase the reaction (Fig. 1). Then, the damaged area was created in the parietal peritoneum on the right side of the abdomen. The cecum was then placed in its normal anatomical position. Subsequently, the abdominal wall of the rats was closed continuously with 3/0 Vicryl and the skin was sutured one by one with 3/0 silk sutures. In the control group, after the experimental study model was created, the incision was closed without any additional intervention. In the sham group, the experimental model was created and the incision was closed after 5 cc of 0.09% NaCl was introduced into the peritoneum. In the Fx group, an experimental study model was created, 35 mg/kg FK was completely dissolved in saline, left into the peritoneum and the incision was closed.

Prophylactic or therapeutic antibiotherapy was not given to any group. After the operation, 100 mg/kg paracetamol was mixed into drinking water at 12 h intervals for 2 days for analgesia in all groups.

Rats were anesthetized by intramuscular administration of ketamine and xylazine at a dose appropriate to the experimental model on the 21st post-operative day. Following disinfection, maximum vision was achieved by making a U incision and retracting the abdominal walls downward.

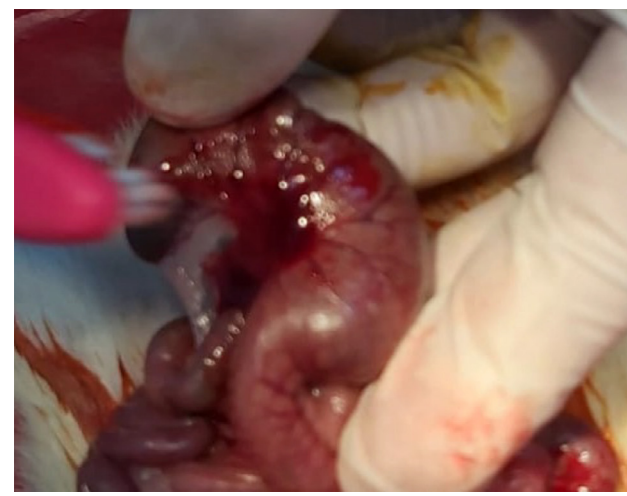

Figure 1. Petechial hemorrhages in the cecum.

Table 1. Mazuji's macroscopic adhesion classification

Grade 0	No adhesion.
Grade 1	Very fine and fragmented irregüler adhesion.
Grade 2	Medium density and fragmented adhesion that can be separated easily.
Grade 3	Intense, not easily separable regular adhesion
Grade 4	Very intense, not easily separable, homogeneous adhesion.

Macroscopic adhesions were quantitatively evaluated according to the Mazuji classification. The evaluation was carried out by two researchers who did not know the groups, according to the classification and in a double-blind manner (Table 1).[9] After macroscopic evaluation, the cecum anterior wall and parietal peritoneum were excised for pathological sampling, including all layers except skin. Rats were sacrificed by intracardiac blood aspiration.

Afterward, the pathological pieces were fixed in containers containing 10% buffered formol. The pieces, which were followed by the classical laboratory method, were stained with hematoxylin-eosin dye and examined by light microscopy. A pathologist, who was unaware of the groups, scored inflammation histopathologically using the inflammation grading scale. Score 0: No inflammation. Score 1: Inflammatory cells around serosal vascular structures. Score 2: Inflammatory cells forming layers in the tissue. Score 3: Inflammatory cells infiltrating all layers of the intestinal wall. Fibroblastic activity was scored histopathologically. Score 0: No activity. Score 1: Increase in fibrous tissue limited to serosa and subserosal tissues. Score 2: Increment of fibrous tissue beyond the muscular layer. Score 3: Increment of fibrous tissue in the entire intestinal wall. In addition, vascular proliferation was scored. Score 0: No vascular proliferation. Score 1: Mild vascular proliferation. Score 2: Moderate vascular proliferation. Score 3: Extensive vascular proliferation.

Serum was obtained by centrifugation of blood taken from rats. Serum levels of pro-inflammatory cytokine tumor necrosis factor-alpha (TNF-α) and anti-inflammatory cytokine interleukin-10 (IL-10) were measured. IL-10 and TNF-α levels were determined by standard enzyme-linked immunosorbent assay (ELISA) method. Any unbound antibody or enzyme reagent was removed by washing with wash buffer. Substrate solution was then added and the absorbance obtained was read at 450 nm using a spectrophotometer (Rat ELISA Kit Abcam, USA).

Statistical Analysis

The statistical analyses were performed using the SPSS statistical software package (version 15.0, IBM; USA). Normality analysis was performed with Shapiro–Wilk test for comparison of classified data between groups. Kruskal–Wallis analysis was used to ensure the normality between groups, considering the small size of the sample included in the study. One-way ANOVA test was used for pairwise comparisons. P<0.05 was considered statistically significant.

Table 2. Macroscopic adhesion rating by groups

Subject	Control	Sham	Fucoxanthin
1 Grade	2	2	1
2 Grade	4	3	1
3 Grade	2	1	0
4 Grade	3	3	1
5 Grade	3	3	1
6 Grade	3	2	1
7 Grade	2	2	1

*Adhesion was significantly less macroscopically in the Fx group compared to the control and sham groups (p<0.001, p<0.001).

RESULTS

No rat was lost during the study period. Congenital adhesion was not observed in any of the subjects at the first laparotomy. There was no wound problem.

The macroscopic evaluation results of the groups according to the Mazuji classification are shown in Table 2. When macroscopic results are evaluated statistically, there was no significant difference in adhesion between the sham group and the control group (p=0.524). It was observed that adhesion was significantly less macroscopically in the Fx group compared to the control group (p<0.001). It was observed that there was a significant difference in adhesion between the sham group and the Fx group, and it was less in the Fx group (p<0.001). Comparison of macroscopic results between groups is shown in Figure 2. Scores 1 and 4 are shown according to the Mazuji scoring in Figure 3a and b.

The values of fibroblastic activity, vascular proliferation, and inflammation scores according to the groups are sum-

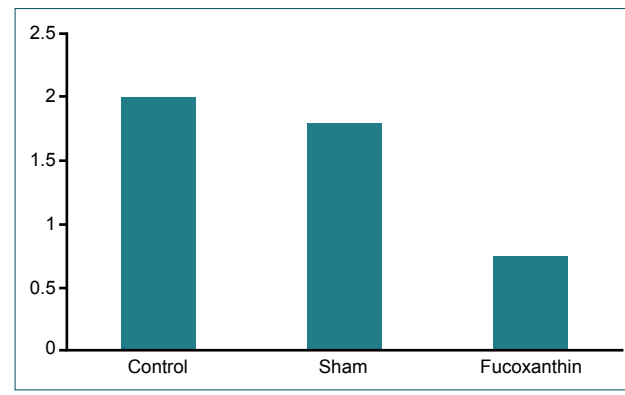

Figure 2. Macroscopic results between groups.

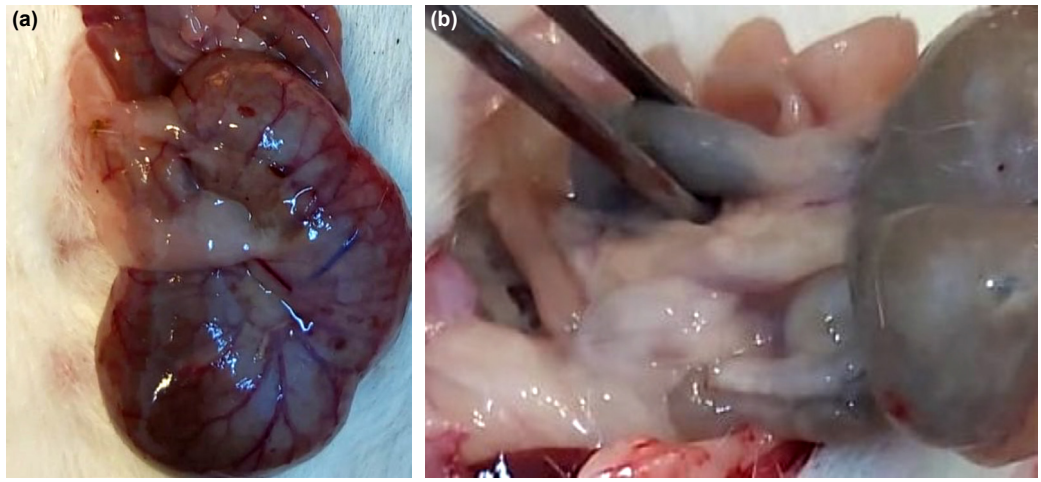

Figure 3. (a) Macroscopic adhesion score 1, **(b)** Macroscopic adhesion score 4.

marized in Tables 3–5. Fibroblastic activity was found to be significantly less in the Fx group compared to the sham and control groups (p<0.001 and p<0.001). Fibroblastic activity was less in the sham group than in the control group, but this difference was not statistically significant (p=0.538). Vascular proliferation was found to be significantly less in the Fx group than in the sham and control groups (p<0.001 and p<0.001). There was no significant difference in vascular proliferation in the sham and control groups (p=0.542). The inflammation score was significantly lower in the Fx group compared to the other two groups (p<0.001 and p<0.001). The inflammation score in the sham group was lower than the control group and was statistically significant (p<0.001). Comparison of histopathological data is shown in Figures 4–6. Microscopic images of histopathological evaluations are shown in Figures 7–9.

Table 3. The values of fibroblastic activity by groups

Subject	Control	Sham	Fucoxanthin
1 Score	3	2	1
2 Score	2	2	1
3 Score	2	1	1
4 Score	2	1	1
5 Score	2	2	1
6 Score	2	2	2
7 Score	3	3	2

*Significantly less in the Fx group compared to the sham and control groups (p<0.001, p<0.001).

Table 4. The values of vascular proliferation by groups

Subject	Control	Sham	Fucoxanthin
1 Score	2	1	1
2 Score	2	2	1
3 Score	2	1	1
4 Score	2	2	1
5 Score	2	2	1
6 Score	2	2	1
7 Score	3	3	2

*Significantly less in the Fx group than in the sham and control groups (p<0.001, p<0.001).

Table 5. The values of inflammation by groups

Subject	Control	Sham	Fucoxanthin
1 Score	2	1	1
2 Score	3	2	1
3 Score	3	1	1
4 Score	2	1	1
5 Score	3	1	1
6 Score	2	2	1
7 Score	3	2	2

*Significantly lower in the Fx group compared to the other two groups (p<0.001, p<0.001). **Significantly less in the sham group compared to the control group (p<0.001).

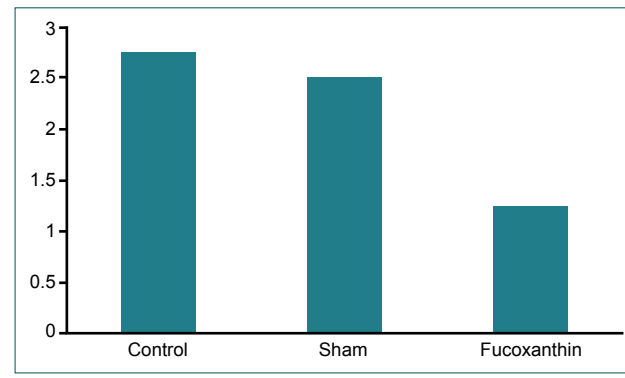

Figure 4. Fibroblastic activity between groups.

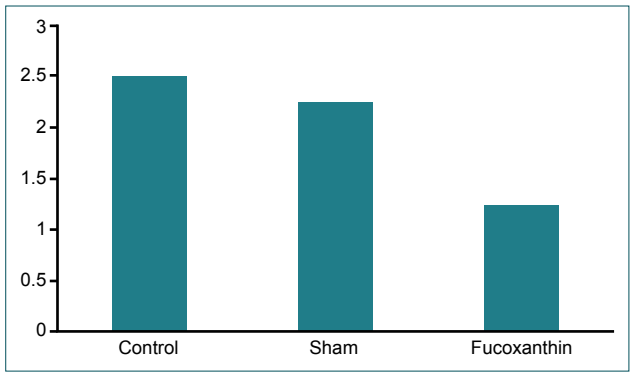

Figure 5. Vascular proliferation between groups.

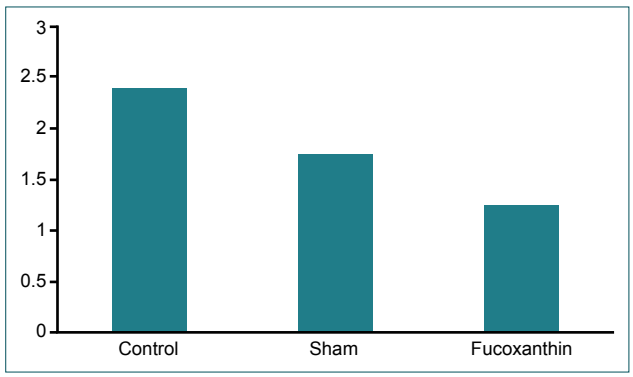

Figure 6. Inflammation score between groups.

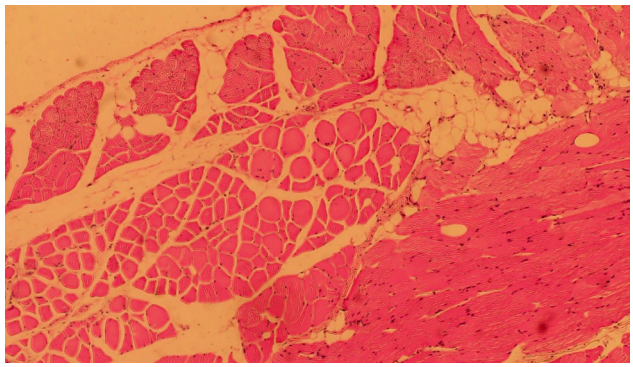

Figure 7. Normal bowel wall (H&E,*100).

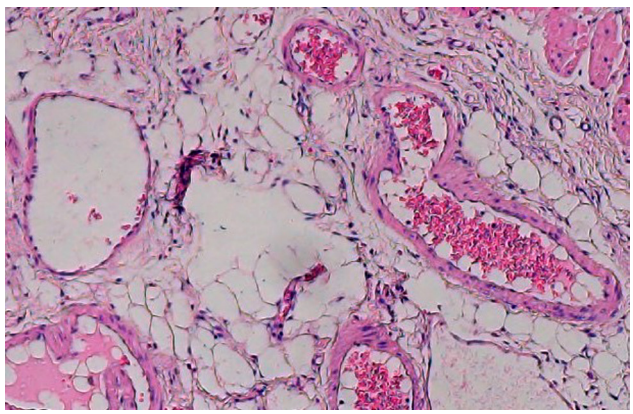

Figure 8. Increased vascularization (H&E,*100).

TNF-α level was found to be statistically significantly lower in the Fx group compared to the sham and control groups

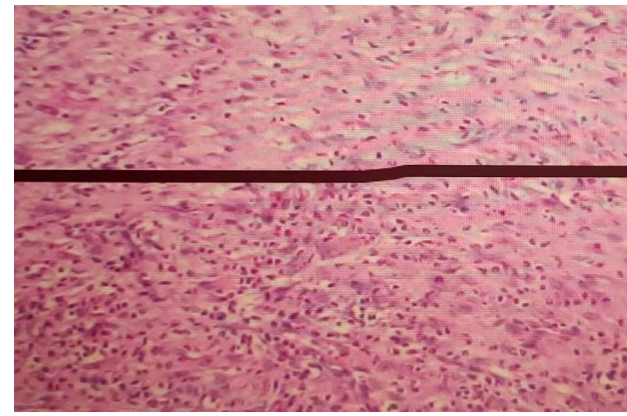

Figure 9. Intense inflammation and fibroblastic activity below the line, little inflammation and fibroblastic activity above the line (H&E, *200).

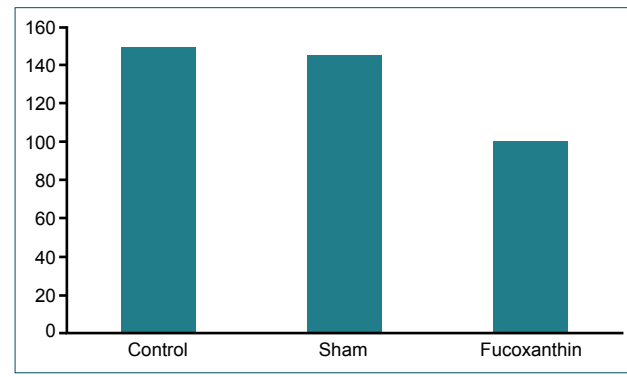

Figure 10. Effect of fucoxanthin on tumor necrosis factor alpha.

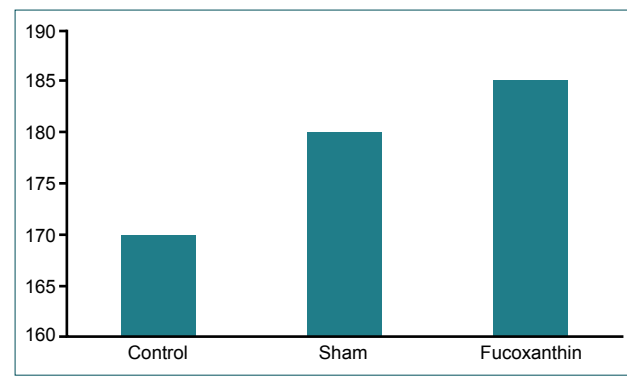

Figure 11. Effect of fucoxanthin on interleukin 10.

($p<0.001$ and $p<0.001$). However, the difference between the sham and control groups was not significant ($p=0.517$). Comparison of values is shown in Figure 10. When IL-10 levels were compared, the highest increase in the groups was in the Fx group compared to the sham and control groups, but the difference was not statistically significant ($p=0.524$ and $p=0.527$). The difference between the sham and control groups was not significant ($p=0.530$). The comparison of IL-10 is shown in Figure 11.

DISCUSSION

To reduce the development of IAA after surgery, efforts should be made to minimize tissue damage, use of appro-

priate suture material and surgical technique, and reduce intraperitoneal hemorrhage and fluid collection. The resulting adhesions make new surgeries difficult and cause serious morbidity such as ileus, infertility, chronic abdominopelvic pain, and sometimes mortality.[10]

Post-operative IAA formation includes pathological processes such as inflammatory response and fibrinolysis imbalance. Therefore, ideal anti-adhesion agents should not damage peritoneal mesothelial cells. It should accelerate wound healing and be completely absorbed from the peritoneum. Substances that are not fully absorbed may cause more adhesion by increasing the inflammatory response. Absorption time should be a maximum of 5 days in accordance with the pathophysiology of adhesion formation.[11] The Fx used in our study is 95% pure and does not leave any particles because it is completely dissolved in saline, and can be completely absorbed from the peritoneum.

Fx is a natural product of carotenoids. It is a potential source of medicine derived from brown seaweed. Fx has various biological activities due to its chemical structure. Studies have shown that fucoxanthin has a potential protective effect on various inflammatory diseases. This effect is thought to be related to fucoxanthin's powerful antioxidant potential and intestinal microbiota regulation.[12] It is known that excessive inflammatory response plays an important role in the development of IAA after surgery.

Although there are studies showing the effectiveness of FC on various diseases in the literature, there are no studies on IAA, so we tried to reveal the possible effect of Fx's strong anti-inflammatory and antioxidant effect on IAA. In the study conducted by Wang et al.,[13] they investigated the Fx effect in the breast cancer MDA_MB_231 xenograft model in nude mice and showed that Fx significantly reduced tumor volume, weight, and inhibited lymphangiogenesis. In the same study, in the cultures in which FK was added in the lymphatic endothelial cell culture, it was observed that tube formation was inhibited during 24 h follow-up.

Maeda et al.[14] showed that Fx improves glucose tolerance in the experimental diabetes model developed in mice. They also showed that fucoxanthiol, an Fx metabolite, acts as an anti-inflammatory agent in the interaction of adipocytes and macrophages, suppressing low-grade chronic inflammation in adipocyte cells and decreasing the production of pro-inflammatory cytokine IL-6. In the same study, they stated that TNF-α level was significantly suppressed in the Fx group compared to the control group. In our study, the low TNF-α level in the Fx group compared to the control and sham groups is consistent with the literature.

In an experimental study conducted by Zheng et al.[15] on mice, they investigated the preventive effects of different doses of Fx on the liver damage caused by alcohol. In this study, they formed groups that received Fx at doses of 10, 30, and 40 mg/kg orally. They found that the relative weight of the liver was lower in all Fx groups compared to the group given only alcohol and the lowest in the group given 40 mg/kg Fx. Body weight was the least affected group was the high dose Fx group. In the same study, in the histopathological examination of the liver, they found that hepatic lobular structures were preserved in all Fx groups, mostly in the high-dose Fx group. As a result of microscopic examination of the gastric mucosa, they have determined that Fx is also protective on the gastric mucosa. In addition, in this study, they showed that Fx can effectively control the secretion of pro-inflammatory factors and have an antioxidant effect. Considering all these results, we used a dose of 35 mg/kg in our study to take maximum advantage of the anti-inflammatory effect of Fx. The lower TNF-α level in the Fx group compared to the other groups is consistent with the literature. In the histopathological examination of the tissues in our study, vascular proliferation, fibroblastic activity, and inflammation score levels were found to be the least in the Fx group, and anti-inflammatory activity is consistent with the literature.

Özbeyli et al.[16] investigated the protective efficacy of Fx and beta-glucan on rats in which pancreatitis developed experimentally and determined the severity of acute pancreatitis histopathologically and biochemically thanks to its anti-inflammatory and antioxidant effects. Fx decreased the level of IL-6, a pro-inflammatory cytokine. They did not find a statistically significant difference in its effect on IL-10. These data in the literature are compatible with our study. We found that the level of TNF-α with pro-inflammatory activity was low in the Fx group, but there was no significant difference in the IL-10 level.

They found that in the experimental rat sepsis model created by Su et al.,[17] the lipopolysaccharide and Fx group significantly reduced the levels of pro-inflammatory cytokines such as IL-6 and TNF-α. In our study, we found that TNF-α was low in the Fx group. These data support the anti-inflammatory activity of Fx.

Yang et al.[18] used pentoxifylline, a phosphodiesterase inhibitor, which has an anti-inflammatory effect by increasing tissue blood flow oxygenation with its hemorheological effects, and found that this drug is effective in reducing adhesions and as an anti-inflammatory.[19] Arslan et al.[20] cordycepin isolated from Cordyceps militaris fungus with potential antineoplastic, antioxidant, and anti-inflammatory activities was used as an anti-adhesion agent. They have shown the anti-adhesion effect. Berkesoglu et al.[21] have experimentally studied the anti-adhesion effect of 2-mercaptoethanesulfonate (mesna) active substance with mucolytic, chemical surgical dissector, and fibrinolytic effect on rats and demonstrated its effectiveness.[22] Rasti et al.[23] in a comparative study with diphenhydramine hydrochloride and nedocromil sodium agents, they showed that both agents prevent adhesion, but nedocromil sodium is more effective. In the experimental study conducted by

Chaturvedi et al.,[24] they investigated the efficacy of the ultra-pure alginate-based gel as an anti-adhesion agent developed bacterial peritonitis, and as a result, they found that the anti-abscess effect was the same as the control group, but the adhesion score was lower in the gel group. Khorshidi et al.[25] investigated the efficacy of sodium hyaluronate, sesame oil, honey, and silver nanoparticles in preventing post-operative surgical adhesion formation in an experimental study and found that sodium hyaluronate and sesame oil were more effective in preventing adhesion.

More than a century has passed since the first definition of fatal bowel obstruction due to IAA.[26] When the literature to prevent adhesions due to previous intra-abdominal surgeries is reviewed, it is seen that studies have been conducted with many different drugs and products such as heparin solution, tissue plasminogen activators, hyaluronic acid solution, protein concentrates, transforming growth factor-beta isoforms, and neurokinin-1 receptors. Although successful results have been obtained at the experimental level in most of the studies, the optimum and effective agent in routine use for the prevention of IAA has not yet been found.[27,28] In our study, we organized this experimental study to investigate the efficacy of Fx, a xanthophyll whose anti-inflammatory and antioxidant activity has been clearly demonstrated in different studies, on IAA, and we determined that it reduces adhesion and its anti-inflammatory efficacy.

Conclusion

In spite of many studies, IAAs after surgery continue to be an important health problem and increase health expenditures. When the literature is reviewed, we could not see any study investigating the effectiveness of Fx on IAA. It is the 1st time we work in this aspect. As a result of experimental study, we can say that Fx is effective in preventing IAAs and decreases the level of TNF-α, a pro-inflammatory cytokine. We think that Fx can be a new active ingredient with anti-adhesion and anti-inflammatory effect with more comprehensive and multicenter studies to be conducted.

Ethics Committee Approval: This study was approved by the Dicle University Prof. Dr. Sabahattin Payzın Health Sciences Research and Application Center Experimental Animals Local Ethics Committee (Date: 03.06.2020, Decision No: 2020/22).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: F.Ö., N.B.A.; Design: F.Ö., N.B.A.; Supervision: E.D., A.T.; Resource: Eli.D., F.Ö.; Materials: A.T., A.Ç.; Data: Eli.D., N.B.A.; Analysis: A.Ç., Eli.D.; Literature search: E.D., A.T.; Writing: E.D., A.T.; Critical revision: A.Ç., E.D.

Conflict of Interest: None declared.

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DENEYSEL ÇALIŞMA - *ÖZ*

Fukoksantin uygulamasının karın içi yapışma üzerindeki önleyici etkisi: Deneysel hayvan çalışması

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AMAÇ: İntraabdominal adhezyon (İAA), periton kavitesinde travma, iskemi, enflamasyon ve enfeksiyon gibi sebeplerle mezotelyal tabakada oluşan hasarlanmanın sonucunda ortya çıkar. İAA'nın en sık sebebi geçirilmiş karın cerrahileridir. Ameliyat sonrası yapışıklıklar ince bağırsak tıkanıklığının birincil sebebidir ve bağırsak tıkanıklığı için başvuruların %70'ini oluşturur. Tüm laparotomilerin yaklaşık %3'ü adezyonlarla ilgilidir. Fukoksantin (FK) antienflamatuvar, antitümör, antiviral etkili bir karotenoiddir. Bu çalışmada, sıçanlarda deneysel olarak oluşturan karın içi cerrahi yapışıklık modelinde FK'nın İAA üzerine önleyici etkisini araştırmak amaçlanmıştır.
GEREÇ VE YÖNTEM: Çalışmada her biri yedi denekten oluşan üç ayrı grup oluşturuldu. Standart anestezi ve sterilizasyon sağlandıktan sonra karın orta hat açılarak çekum ortaya kondu. Steril bir diş fırçası ile çekumda ve karın duvarı sağ yanda peteşial kanama görülene kadar hasar oluşturuldu. Reaksiyonu arttırmak için 5/0 vikrille çekuma dikiş atıldı. Kontrol grubuna ek işlem yapılmadı. Sham grubunda 5 cc serum fizyolojik periton içine bırakıldı. FK grubunda ise 35 mg/kg FK periton içine bırakıldı ve karın kapatıldı. Tüm denekler 21 gün yaşatıldı. Ameliyat sonrası 21. günde deneklere anestezi uygulandı. Makroskopik olarak Majuzi skorlama sistemine göre adezyonlar skorlandı. Sonrasında çekum duvarı ve hasarlı peritondan histopatolojik inceleme için kesit alındı. Enflamasyon skoru, fibroblastik aktivite ve vasküler proliferasyon histopatolojik olarak değerlendirildi. İntrakardiyak kan aspirasyonu ile denekler sakrifiye edildi. Alınan kan santrifüj edilerek serumda proenflamatuvar sitokin tümör nekrozis faktör alfa (TNF-α) ve antienflamatuvar sitokin interlökin 10 (IL-10) düzeyine bakıldı.
BULGULAR: Makroskopik incelemede Majuzi skorlama sistemine göre FK grubunda belirgin olarak diğer gruplara göre adezyon daha az görüldü ($p<0.001$, $p<0.001$). Histopatolojik incelemede fibroblastik aktivite, enflamasyon skoru ve vasküler proliferasyon FK grubunda diğer gruplara göre anlamlı düzeyde düşüktü ($p<0.001$, $p<0.001$). Ayrıca enflamasyon skoru sham grubunda kontrol grubuna göre istatistiksel olarak anlamlı olacak düzeyde düşüktü ($p<0.001$). TNF-α düzeyi kontrol ve sham grubuna göre düşüktü ve istatistiksel olarak anlamlı idi ($p<0.001$, $p<0.001$). IL-10 düzeyinde ise gruplar arasında anlamlı fark görülmedi.
TARTIŞMA: Cerrahi sonrası karın içi yapışıklıklar yapılan birçok çalışmaya rağmen günümüzde önemli bir sağlık sorunu olmaya ve sağlık harcamalarını arttırmaya devam etmektedir. Daha kapsamlı ve çok merkezli çalışmalar sonucunda Fukoksantinin adezyon önleyici ve antienflamatuvar etkili yeni bir etken madde olabileceğini düşünmekteyiz.
Anahtar sözcükler: Adhezyon; fukoksantin; karın içi yapışıklık; proenflamatuvar sitokin.

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