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ORIGINAL ARTICLE

Omentopexy as a novel adjunct to detorsion in ovarian torsion: experimental evidence

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ABSTRACT

Objective: In the treatment of ovarian torsion, the primary goal is to preserve the ovary through detorsion, even when it appears blue-black. However, no routinely applied method currently exists to prevent ischemia-reperfusion (I/R) injury that occurs after detorsion. The aim of this study is to evaluate the effect of wrapping the detorsioned ovary with omentum in preventing I/R associated tissue damage

Materials and Methods: Fifteen Sprague–Dawley rats were randomly assigned to three groups (n = 5 each). In the sham group, laparotomy was performed, and the abdomen was closed without further intervention. In the control group, the left ovary was rotated 720° clockwise and fixed to the anterior abdominal wall, followed by omentectomy. After 24 hours, laparotomy was repeated and the ovary was detorsioned. In the experiment group, the left ovary was rotated 720° clockwise and fixed to the anterior abdominal wall. After 24 hours, laparotomy was repeated, the ovary was detorsioned, and then wrapped in omentum. Twenty-one days after the first surgery, oophorectomy was performed in all groups. Ovarian tissues were histopathologically examined for congestion, interstitial edema, neutrophilic infiltration, and necrosis, and overall tissue damage scores were calculated.

Results: There was no significant difference between the sham and experiment groups regarding overall tissue damage ($p = 0.171$). However, the control group had significantly higher tissue damage compared to the sham group ($p = 0.001$). Necrosis was observed in two ovaries of the control group, whereas no necrosis was seen in the sham or experimental groups. Viable follicles were detected in only two rats in the control group, while all rats had viable follicles in the sham and experiment groups.

Conclusion: Omentopexy was found to be effective in tissue healing. Wrapping the ovary with omentum after detorsion may help preserve ovarian function and maintain follicular viability.

Keywords: omentopexy, ovarian torsion, detorsion, ischemia reperfusion injury

INTRODUCTION

Ovarian torsion is the most frequent gynecologic emergency in children. It accounts for 2.7% of acute abdominal pain cases in children [1]. Historically, oophorectomy was the choice of treatment due to concerns for thromboembolism and malignancy risk [2]. However, studies have demonstrated that there is no increase in the risk of thromboembolism or malignancy after detorsion when compared to oophorectomy as previously supposed [3-5]. Currently, detorsion and preservation of the ovary is the treatment of choice. However, some of the untwisted ovaries vanish after the operation and some fail to have healthy follicles [6]. There is not any clinical, laboratory or image defined study to demonstrate the viability of the untwisted ovary. Even a blue-black appearance of the ovary resembling necrotic tissue does not indicate irreversible damage [7,8].

The tissue damage in the untwisted ovary is secondary to direct damage caused by ischemia itself and reperfusion injury [9,10]. Decreased ovarian circulation due to torsion cause an ischemic damage histologically confirmed with edema, inflammatory infiltration, necrosis, vascular congestion and follicular degeneration. Ovarian blood flow may be only partial or slow after untwisting and ischemic injury can go on. Furthermore, maintaining the circulation after detorsion may cause oxidative stress and worsen the damage leading ischemia/reperfusion (I/R) injury [9,10]. Animal studies demonstrated many effective methods to prevent I/R injury of ovary. However, there is not any clinically proven method to protect the structure and function of the untwisted ovary.

Omentum exerts angiogenic activity in adjacent organs by secreting angiogenic cytokines and accelerates healing in ischemic or inflamed tissue [11]. Surgically approximation of an omentum flap helps revascularization of ischemic tissue [12]. In addition, it is known that omentum helps the perfusion of free tissues such as trachea, small intestine and sciatic nerve grafts [13,14]. Ability of omentum to promote healing and regeneration is clinically used in treatment of traumatic and surgical wounds, restructuring soft tissue defects and in supporting tissue healing [15]. Given the potential healing properties of omentum, we hypothesize that omentopexy can decrease tissue damage and improve recovery after detorsion of the torsed ovary. The aim of this study is to evaluate whether omentopexy decreases ischemic tissue damage and I/R injury of the untwisted ovary in an animal model of ovarian torsion or not.

METHODS AND MATERIAL

The experiment is approved by institutional Animal Experimentations Ethics Board Commission and guidelines for responsible use and animal care were followed strictly.

Animals

Fifteen adult female Sprague Dawley (SD) rats with a mean weight of 220gr (200-250 gr) were used in the study. Animals were fed ad libitum and housed in a temperature-controlled environment (20°C to 22°C) with a relative humidity of 40% to 50% and photoperiod of 12-hours light/12-hours dark. Rats were randomly assigned into three groups: Group I (sham group), Group II (control group) and Group III (experiment group).

Anesthesia

All surgical procedures were performed under general anesthesia. Anesthesia was induced and maintained by intramuscular administration of 10 mg/kg ketamine (Ketalar; Pfizer, İstanbul, Turkey) and 5 mg/kg xylazine (Rhompun; Bayer, İstanbul, Turkey). Rats were maintained on spontaneous respiration throughout the anesthesia. Analgesia was provided with 1mg/mL acetaminophen (Tylol; Nobel İlaç Sanayi ve Ticaret AŞ, İstanbul, Turkey) added to drinking water.

Surgery

All animals were placed in supine position and 4-cm long midline abdominal incision was made under sterile conditions. Mobile viscera were exteriorized within a saline soaked towel.

In group I abdominal wall was closed without any further intervention.

In Group II left ovary was rotated for 720 degrees clockwise and fixed to anterior abdominal wall with 3/0 silk suture (İpek; Doğsan, İstanbul, Turkey).

All the rats in Group II had omentectomy. Twenty-four hours after the first operation left ovary was untwisted and left free in the abdominal cavity.

In group III left ovary was rotated clockwise for 720 degrees and fixed to anterior abdominal wall with 3/0 silk suture (İpek; Doğsan, İstanbul, Turkey). Twenty-four hours after the first operation left ovary was untwisted. The omentum flap was approximated to left ovary. Omentopexy was completed by wrapping the omentum around left ovary.

Twenty-one days after the first operation, all rats underwent laparotomy and left ovaries were removed.

Histopathological evaluations

Tissue samples were rinsed immediately and fixed in 10% formalin at room temperature for 72 hours and were processed according to routine light microscopic tissue processing. They were dehydrated in ascending degrees ethanol, cleared in xylene and embedded in paraffin. Serial sections of 5 µm was cut and stained with H&E. Sections were photographed with Olympus BH2 light microscope (Olympus, Tokyo, Japan).

Tissue samples were evaluated by a single pathologist in a blinded fashion. Congestion, interstitial edema, neutrophilic infiltration, necrosis and presence of viable follicles were noted. Tissue damage was evaluated by semiquantitative scoring of five examined microscopic areas of each specimen. The score of pathological change was 0, 1, 2 and 3; when there was no, mild (<25% of microscopic areas), moderate (25% to 75% of microscopic areas), severe (>75% of microscopic areas) respectively. Total tissue damage was calculated by addition of congestion, interstitial edema, neutrophilic infiltration and necrosis scores.

Statistical analysis

The statistical package SPSS for Windows 21.0 (Statistical Package for Social Sciences; SPSS Inc, Chicago, Illinois) was used to analyze data. Kruskal-Wallis test, Fischer's exact test and Chi-square test were used for analysis. P values less than 0.05 were considered statistically significant.

RESULTS

In group I, specimens of two rats had vascular congestion, and none had interstitial edema, neutrophilic infiltration or necrosis. In group II specimens of all rats had vascular congestion, interstitial edema and neutrophilic infiltration and two rats had necrosis (Figure 1, 2). In group III specimens of all rats had vascular congestion and neutrophilic infiltration, one had interstitial edema, and none had necrosis (Figure 3). There were healthy ovarian follicles in specimens of all rats in group I and III. Specimens of two rats in group II had healthy ovarian follicles. There were statistically significant differences among groups in terms of presence of interstitial edema, neutrophilic infiltration and presence of healthy follicles (Chi-square test, $p<0.05$).

Histopathological examination scores are shown in Table 1.

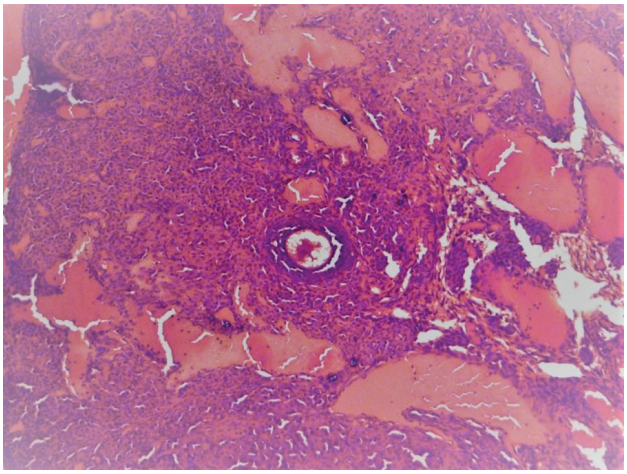

Figure 1. Group II: marked congestion, interstitial edema and neutrophilic infiltration (H&E, x100)

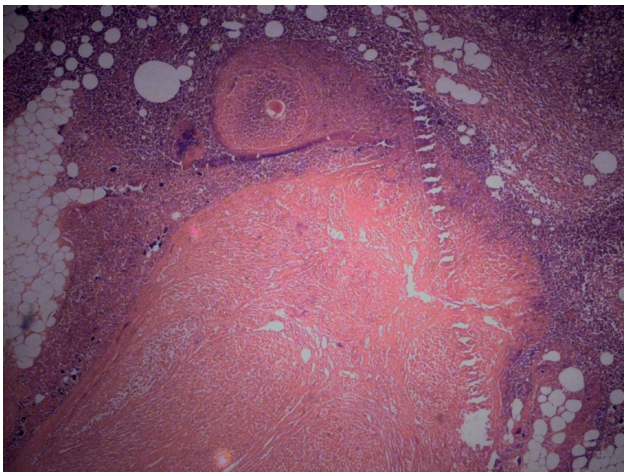

Figure 2. Group II: necrotic ovary (H&E, x100)

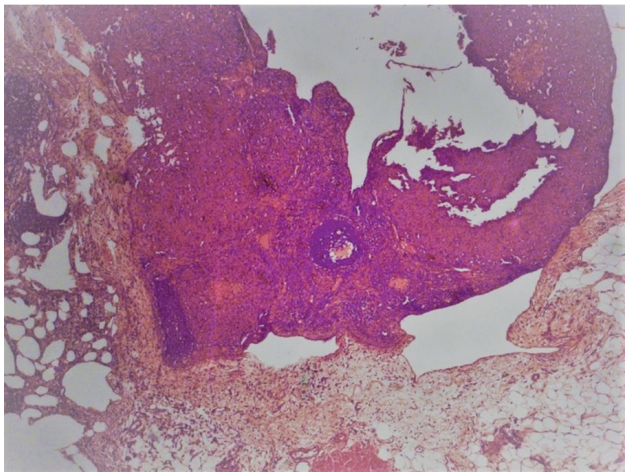

Figure 3. Group III: ovary wrapped with omentum (H&E, x100)

There was statistically significant difference between groups in histopathological scores of interstitial edema and neutrophilic infiltration (Kruskal Wallis, $p<0.05$). In group II, histopathological examination scores of interstitial edema and neutrophilic infiltration were higher than Group I and Group III (Fischer's exact test, $p<0.05$). The interstitial edema and neutrophilic infiltration scores of Groups I and III were not significantly different (Fischer's exact test, $p>0.05$).

Total tissue damage score of Group II was higher than Group I and III (Fischer's exact test, $p<0.05$).

In group II a smaller number of rats had healthy follicle than Group I and III (Fischer's exact test, $p<0.05$). there was not any statistically significant difference between Group I and Group III in terms of presence of healthy follicle (Fischer's exact test, $p>0.05$).

DISCUSSION

Ovarian torsion and it's I/R consequences have been extensively investigated in experimental settings. However, most previous studies employed ischemia durations of only 2-4 hours which may be insufficient to induce significant and reproducible ischemic damage in the ovary [16]. The present study used a 24-hour ischemia model, which resulted in marked histopathological injury, including vascular congestion, interstitial edema, neutrophilic infiltration, necrosis and follicular loss. This prolonged ischemia model therefore provides a more reliable framework to evaluate potential protective strategies.

Restoration of blood flow after detorsion can paradoxically exacerbate ovarian injury through reperfusion mechanisms. Increased production of reactive oxygen species, activation of macrophages and endothelial cells, and neutrophil recruitment contribute to a cascade of inflammatory events.

Table 1. Tissue damage scores

	Vascular Congestion	Interstitial Edema	Neutrophilic Infiltration	Necrosis	Total Tissue Damage
Group Ia	0	0	0	0	0
Group Ib	3	0	0	0	3
Group Ic	3	0	0	0	3
Group Id	0	0	0	0	0
Group Ie	3	0	0	0	3
Group I	**1,8±1,6**	**0±0**	**0±0**	**0±0**	**1,8±1,6**
Group IIa	3	3	3	0	9
Group IIb	3	3	3	3	12
Group IIc	3	3	3	0	9
Group IId	3	3	3	0	9
Group IIe	3	3	3	3	12
Group II	**3±0**	**30**	**3±0**	**1,2±1,6**	**10,2±1,6**
Group IIIa	3	0	1	0	4
Group IIIb	3	0	2	0	5
Group IIIc	3	3	3	0	9
Group IIId	3	0	3	0	6
Group IIIe	3	0	1	0	4
Group III	**3±0**	**0,6±1,3**	**2±1**	**0±0**	**5,6±2**

[17,18]. Activated neutrophils cluster within capillaries, impairing microvascular perfusion and amplifying tissue edema [19]. In turn, cytokines and chemokines perpetuate neutrophil activation and infiltration, sustaining tissue damage and follicular loss [20]. While numerous experimental interventions have been proposed to mitigate I/R injury, no clinically applicable protective method has yet been established.

In the current study, omentopexy significantly attenuated histopathological markers of I/R injury. Interstitial edema and neutrophilic infiltration scores were significantly lower in the omentopexy group compared with the detorsion-only group, while not differing significantly from the sham group. Moreover, the preservation of healthy follicles was markedly higher with omentopexy. Total tissue damage scores were also reduced in the omentopexy group, further supporting protective role.

The beneficial effects of omentum are likely multifactorial. Its rich vascular network and secretion of angiogenic mediators, such as VEGF, promote revascularization. It's lymphatic drainage capacity reduces tissue edema and facilitates clearance of inflammatory mediators. Furthermore, the omentum contains mesenchymal stem cells and immune cell-rich milky spots that release growth factors, chemotactic signals, and progenitor cells to support regeneration of injured tissue [11,18,21]. These mechanisms collectively explain the histopathological improvements observed in the omentopexy group.

Although no statistically significant difference in necrosis was observed among groups, it's noteworthy that all necrotic samples and all specimens without viable follicles were confined to the detorsion-only group. This finding suggests that omentopexy may enhance perfusion and preserve follicular viability, even if the limited sample size precluded statistical significance.

Taken together, this experimental study provides significant preclinical evidence that omentopexy performed on detorsed ovaries reduces ischemia-reperfusion injury and contributes to the preservation of ovarian function. These findings highlight the potential clinical relevance of omentopexy as an adjunct to detorsion in ovarian torsion. Nevertheless, further studies including biochemical markers, functional ovarian reserve testing, and long-term fertility outcomes are warranted before translation to clinical practice.

Author contribution

Study conception and design: GŞ, SE, ZA; data collection: GŞ, SE; analysis and interpretation of results: GŞ, SE, ZA; draft manuscript preparation: GŞ, SE. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the Hacettepe University Local Ethics Committee (Protocol no. 52338575-121/October 18, 2016).

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Conflict of interest

The authors declare that there is no conflict of interest.

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