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Research

The TAP Block Reduces Oxidative Stress and Postoperative Pain in Laparoscopic Gynecological Surgery

TAP Bloğu Laparoskopik Jinekolojik Cerrahide Oksidatif Stresi ve Postoperatif Ağrıyı Azaltır

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ABSTRACT

Objective: Postoperative pain is a significant concern in laparoscopic gynecological surgery, and its management typically includes regional analgesia techniques, such as the transversus abdominis plane (TAP) block, alongside systemic analgesics. Thiol-disulphide homeostasis (TDH) measurements are used to assess oxidative stress. This study investigated the effect of TAP block on TDH and postoperative pain.

Methods: The study included patients who underwent laparoscopic total abdominal hysterectomy and bilateral salpingo-oophorectomy. While a TAP block was performed following anesthesia induction in Group T, local anesthetic infiltration was administered at the trocar insertion sites prior to trocar placement in Group I. Blood samples were taken at anesthesia induction and at the 24th postoperative hour.

Results: In Group T, we observed higher levels of native thiol (NT), total thiol (TT), and the NT/TT ratio, whereas disulphide/NT and disulphide/TT ratios, and ischemia-modified albumin values were lower than in Group I. Additionally, postoperative pain scores were lower in Group T at 0, 2, and 4 hours.

Conclusion: In this study, we found that TAP block combined with general anesthesia reduced oxidative stress and postoperative pain. We conclude that the combination of general anesthesia and regional analgesia has beneficial effects on both oxidative stress and pain management.

Keywords: Laparoscopic gynecological surgery, oxidative stress, pain, regional anesthesia, thiol-disulphide homeostasis, transversus abdominis plane block

ÖZ

Amaç: Laparoskopik jinekolojik cerrahilerde postoperatif ağrı önemli bir sorundur ve yönetiminde sistemik analjeziklere ek olarak transversus abdominis plan (TAP) bloğu gibi rejyonal analjezi teknikleri kullanılmaktadır. Tiyol-disülfit homeostazı (TDH) ölçümleri, oksidatif stresin değerlendirilmesinde kullanılmaktadır. Bu çalışmada, TAP bloğunun TDH ve postoperatif ağrı üzerindeki etkisi araştırılmıştır.

Gereç ve Yöntem: Çalışmaya laparoskopik total abdominal histerektomi ve bilateral salpingo-ooforektomi uygulanan hastalar dahil edilmiştir. Grup T'ye anestezi indüksiyonunu takiben TAP blok uygulanırken, Grup I'ya trokar yerleştirme işlemi öncesinde trokar yerlerine lokal anestezik infiltrasyonu uygulandı. Kan örnekleri anestezi indüksiyonu sırasında ve postoperatif 24. saatte alınmıştır.

Bulgular: Grup T'de, Grup I'ya kıyasla daha yüksek düzeyde natif tiyol (NT), total tiyol (TT) ve NT/TT oranı saptanırken, disülfit/NT, disülfit/TT oranları ve iskemi-modifiye albümin değerleri daha düşük bulunmuştur. Ayrıca, Grup T'de postoperatif ağrı skorları 0, 2 ve 4. saatlerde daha düşük seyretmiştir.

Sonuç: Bu çalışmada, genel anestezi ile kombine edilen TAP bloğunun oksidatif stresi ve postoperatif ağrıyı azalttığını bulduk. Genel anestezi ile rejyonal analjezi kombinasyonunun, hem oksidatif stres hem de ağrı yönetimi açısından olumlu etkiler sağladığı sonucuna vardık.

Anahtar Kelimeler: Laparoskopik jinekolojik cerrahi, oksidatif stres, ağrı, rejyonal anestezi, tiyol-disülfit homeostazı, transversus abdominis plan bloğu

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INTRODUCTION

Although laparoscopic gynaecological surgery is considered less invasive than open gynaecological surgery, it still results in postoperative pain. In laparoscopic procedures, surgical trauma and pneumoperitoneum are significant contributors to postoperative discomfort (1). Inadequate management of postoperative pain may lead to decreased patient comfort, extended hospital stays, and the development of chronic pain. Postoperative pain is typically managed with systemic analgesics, local anaesthetic infiltration, and regional anaesthesia techniques (2,3).

Thiols interact with free radicals to form disulfides, thereby mitigating oxidative stress (4,5). The method of quantitatively measuring serum thiols is commonly employed to assess dynamic thiol-disulfide homeostasis (TDH). Dysregulations in TDH have been linked to degenerative and proliferative diseases. In addition, ischemia-modified albumin (IMA) is frequently utilized as a biomarker for oxidative stress in various conditions (6-8). Reduced native thiol (NT) and total thiol (TT) levels, increased disulphide thiol (DT) concentrations, and elevated IMA levels are associated with heightened oxidative stress (9,10).

The effects of different regional analgesia techniques on pain and oxidative stress have been investigated using various biochemical markers, including malondialdehyde, superoxide dismutase, and nitrotyrosine. (11,12). Surgical trauma induces tissue injury, which leads to increased sympathetic nervous system activity and the release of proinflammatory cytokines. This heightened inflammatory response is known to contribute to elevated levels of oxidative stress. Regional anesthesia techniques, by providing effective analgesia, have been shown to suppress the neuroendocrine stress response and consequently decrease the release of inflammatory cytokines (13-15).

This study aims to investigate the hypothesized positive effects of the transversus abdominis plane (TAP) block on TDH during laparoscopic gynecological surgery. Our secondary objective is to explore the effects of TAP block on IMA and postoperative pain.

METHODS

Trial Design

This single-centre, randomised controlled study complied with the ethical standards of the Declaration of Helsinki. Approval for the study was obtained from the Ethics Committee of University of Health Sciences Türkiye, Ankara Etlik City Hospital No. 1 Clinical Research (approval no: 037, date: 05.04.2023). Written informed consent was obtained from all the participants.

Participants

The study included patients aged between 18 and 80 years, classified as American Society of Anesthesiologists physical status I-II, who underwent laparoscopic total abdominal hysterectomy and bilateral salpingo-oophorectomy (TAH-BSO). Exclusion criteria were allergy to local anesthetics, chronic analgesic use, coagulopathy, surgical-site infection, neuropathy, chronic pain syndrome, and intraoperative complications.

Randomization

After patients who met the inclusion criteria were identified, they were divided into two groups. Patients were numbered sequentially and allocated to groups using opaque, sealed envelopes: those receiving a TAP block (Group T) and those not receiving it (Group I). Random identification numbers were assigned to patients, and a blinded anesthesiologist collected postoperative data using them (Figure 1). Surgical procedures in both groups were performed by the same surgical team. The anesthesiologist who collected postoperative data, the surgical team, and the patients were blinded to group allocation.

Interventions

All patients were monitored with standard techniques, including electrocardiography, pulse oximetry, non-invasive blood pressure, and bispectral index (BIS). Both patient groups received induction of anesthesia with propofol (2 mg/kg), lidocaine (1 mg/kg), fentanyl (1 mcg/kg), and rocuronium (0.6 mg/kg). Anesthesia was maintained with sevoflurane and a remifentanil infusion [0.05-0.3 mcg/kg/min intravenous (IV)], targeting a BIS value of 40-60. The remifentanil infusion dose was adjusted according to the patient's intraoperative hemodynamic parameters. The remifentanil dose was increased if the heart rate or the systolic blood pressure increased by more than 20%. Balanced fluid resuscitation was applied as the standard approach in both groups. IV tramadol (100 mg) and paracetamol (1 g) were administered for analgesia, and ondansetron (4 mg) was given as an antiemetic to all patients 20 minutes before the end of surgery. Neuromuscular blockade was reversed with 50 mcg/kg IV neostigmine and 10 mcg/kg IV atropine. After extubation, patients were transferred to the postanesthesia care unit.

Following anesthesia induction, patients in Group T received a bilateral subcostal TAP block with 30 mL of 0.25% bupivacaine (15 mL on each side). A subcostal

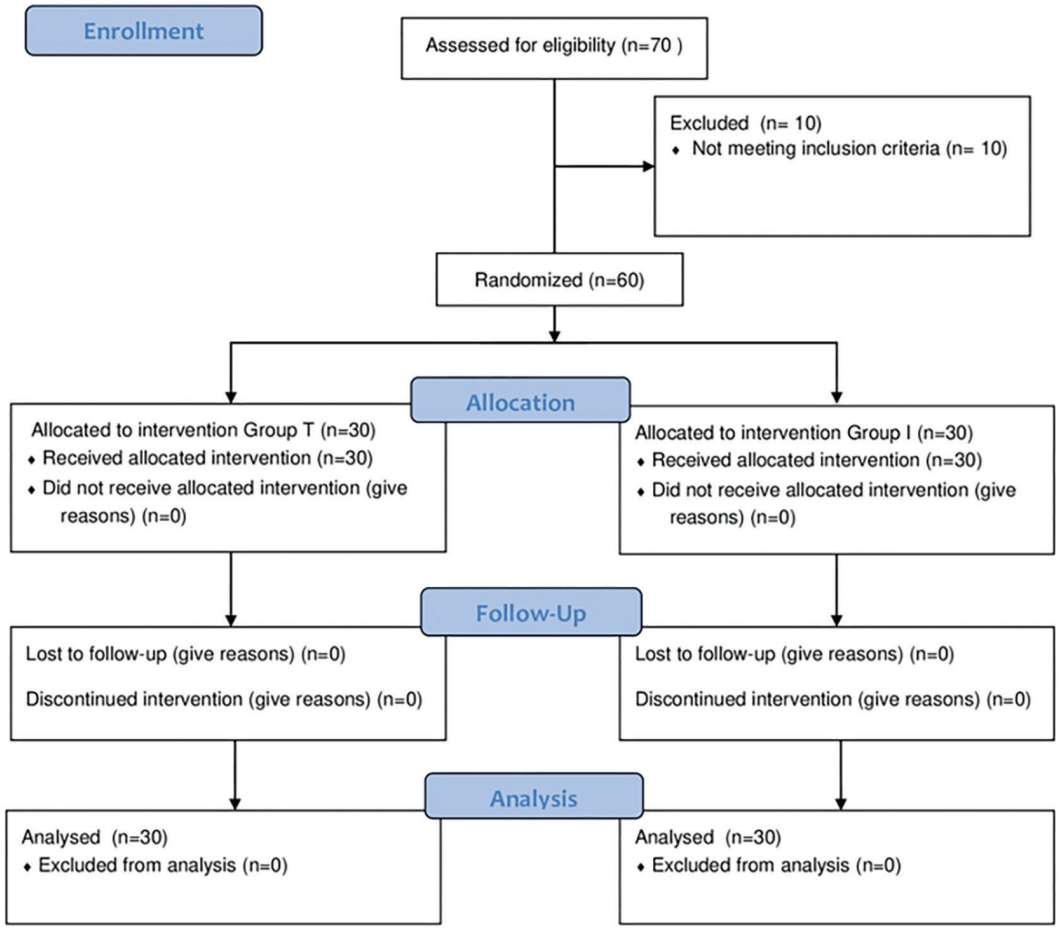

Figure 1. CONSORT diagram of the study
CONSORT: Consolidated standards of reporting trials

TAP block was performed by the same experienced anesthesiologist. A high-frequency (6-13 MHz) linear transducer (Sonosite, Bothell, Washington, USA) and an 80 mm 22G needle (Sonoplex, Pajunk, Geisingen, Germany) were used for the procedure. The needle was inserted in-plane from medial to lateral and advanced until it reached the plane between the internal oblique and transversus abdominis muscles. After confirming correct needle placement, 15 mL of 0.25% bupivacaine was injected. The same procedure was then performed on the contralateral side.

In Group I, 30 mL of 0.25% bupivacaine was infiltrated into the four trocar sites prior to trocar placement. The same experienced surgeon performed local anesthetic infiltration.

In this study, 3 mL blood samples were obtained from patients before induction of anesthesia (T1) and 24 hours postoperatively (T2). TDH and IMA levels were analyzed in the same blood samples. TDH tests were performed using the spectrophotometric assay described by Erel and Neselioglu (9), Erel and Erdoğan (10). The albumin cobalt binding test was used to evaluate IMA.

Standard Analgesia Protocol

All patients routinely received two 1 g doses of paracetamol and two 100 mg doses of tramadol in the postoperative period. Patients with a Numerical Rating Scale (NRS) pain score above 4 were administered 50 mg of dexketoprofen as a rescue analgesic.

Outcomes

The primary outcome of the study was TDH in both groups. Secondary outcomes included IMA, pain scores, and rescue analgesic consumption. Patients' pain scores on the NRS and consumption of rescue analgesics were assessed at 0, 2, 4, 8, 12, and 24 hours.

Statistical Analysis

SPSS 21.0 was used in the study. Shapiro-Wilk test (for normality), Student's t-test (for continuous, normally distributed variables), Mann-Whitney U test (for non-normally distributed variables), and chi-square test (for categorical variables) were used. The sample size was calculated using G*Power based on data from a preliminary study. A total of 10 patients were included in the preliminary study, with 5 patients in each group. Data from these patients were not included in the main study analysis. In the preliminary study, NT (mean±standard deviation) was 320.08±4.53 in Group T and 316.50±4.78 in Group I. Using alpha=0.05, beta=0.20, and effect size=0.76, the minimum required sample size was calculated to be 56.70 patients were included to allow for dropouts.

RESULTS

The study group consisted of patients who underwent laparoscopic TAH-BSO between July 15, 2023, and December 15, 2023 (Figure 1). Demographic characteristics and comorbidities were similar across groups (Table 1). The mean surgical durations for Group T and Group I were 122.33±16.38 minutes and 120.17±10.54 minutes, respectively (p=0.545) (Table 1). Mean arterial pressure was recorded intraoperatively at 0, 30, 60, and 90 minutes. In Group T, these values were 92.10±4.50, 87.23±4.43, 85.97±3.78, and 86.57±3.90, respectively. In Group I, the values were 91.77±4.77, 86.80±4.07, 87.00±3.23, and 87.07±2.91. Mean arterial pressure was similar between groups during the intraoperative period (p>0.05). Remifentanil consumption was found to be 0.74±0.15 mg in Group T and 0.80±0.16 mg in Group I (p=0.207) (Table 1). Preoperative TDH values were similar across groups (Table 2). During the postoperative period, the values of DT/NT, DT/TT, and IMA were lower in Group T, while NT, TT, and the NT/TT ratio were higher in Group T (Table 2). In Group T, thiol values in T1 and T2 were similar (p>0.05). In Group I, we observed decreases in NT, TT, and the NT/TT ratio, and increases in DT/NT, DT/TT, and IMA at T2 compared with T1 (Table 2). We found lower NRS scores in Group T at 0, 2, and 4 hours (Table 3). The time to first rescue analgesic was 135.83±30.45 minutes in Group T and 91.67±27.92 minutes in Group I (p<0.001). Total dexketoprofen consumption as a rescue analgesic was 58.33±18.95 mg in Group T and 76.66±31.44 mg in Group I (Table 3).

DISCUSSION

In this study, we investigated the effect of TAP block on TDH and postoperative pain in laparoscopic gynecological surgery. Our results demonstrated that the group receiving the TAP block had higher NT, TT, and NT/TT values, whereas DT/NT and DT/TT ratios and IMA levels were lower. Additionally, the TAP block group had lower pain scores at 0, 2, and 4 hours postoperatively. TDH values in the TAP block group remained stable between the preoperative and 24-hour postoperative time points. In contrast, the group that did not receive the TAP block exhibited decreases in NT, TT, and NT/TT ratios, accompanied by increases in DT/NT and DT/TT ratios and in IMA levels in the postoperative period compared with the preoperative period.

Omür et al. (16) compared combined epidural anaesthesia with general anaesthesia in caesarean section surgeries. They found higher IMA values and increased oxidative stress in patients receiving general anesthesia. Another study that examined the effects of spinal and general anaesthesia on TDH reported similar NT and TT values but lower DT values in the spinal anaesthesia, suggesting reduced oxidative stress in patients who received spinal anaesthesia (17). Furthermore, a study comparing the effects of interscalene block with general anaesthesia in shoulder arthroscopy found higher NT and TT values in patients receiving interscalene block (18). In alignment with these findings, this study demonstrated that patients who received the TAP block had higher levels of NT, TT and NT/TT ratios, while DT/NT, DT/TT ratios and IMA levels were lower compared to another group. We suggest that the changes in TDH observed in our study indicate that

Table 1. Demographic and clinic characteristic

	Group T (n=30)	Group I (n=30)	p-value
Age (year)	50.43±10.87	51.70±11.88	0.668
BMI (kg/m^2)	26.38±3.11	27.41±3.05	0.201
ASA score (n)			
I	5	6	0.739
II	25	24	
Surgery time (minute)	120.17±10.54	122.33±16.38	0.545
Comorbidity (n)			
Asthma	3	6	0.278
Coronary artery disease	4	2	0.389
Diabetes mellitus	3	4	0.688
Hypertension	7	6	0.754
Rheumatological disease	5	4	0.718
Psychiatric disease	2	4	0.389
Thyroid disease	6	8	0.542
Remifentanil consumption (mg)	0.74±0.15	0.80±0.16	0.207

Values are presented as mean±standard deviation and numbers
n: Number, BMI: Body mass index, ASA: American Society of Anesthesiologists

Table 2. Thiol/disulphide redox states according to groups and times

Parameter	Group T	p*	Group I	p*	p#
Native thiol, µmol/L					
Preoperative	333.78±79.81	0.793	333.15±84.03	**0.017**	0.976
Postoperative	328.88±62.80		278.42±87.88		**0.013**
Total thiol, µmol/L					
Preoperative	383.47±86.60	0.620	380.48±85.35	**0.026**	0.891
Postoperative	373.90±64.43		327.27±95		**0.03**
Disulphide, µmol/L					
Preoperative	24.84±4.81	0.051	23.65±4.20	0.504	0.313
Postoperative	22.51±4.27		24.42±4.63		0.101
Native thiol/total thiol					
Preoperative	86.55±2.88	0.138	86.91±3.72	**0.007**	0.673
Postoperative	87.65±2.78		84.03±4.27		**<0.001**
Disulphide/native thiol					
Preoperative	7.80±1.91	0.146	7.63±2.59	**0.01**	0.771
Postoperative	7.09±1.80		9.66±3.29		**<0.001**
Disulphide/total thiol					
Preoperative	6.70±1.44	0.150	6.53±1.86	**0.007**	0.701
Postoperative	6.17±1.39		7.98±2.13		**<0.001**
IMA					
Preoperative	0.70±0.03	0.681	0.70±0.02	**0.01**	0.622
Postoperative	0.71±0.01		0.72±0.02		**0.046**

p<0.05 was considered significant
*: Intra-group preoperative and postoperative values were compared, #: Values between groups were compared, IMA: Ischemia-modified albumin

Table 3. Pain scores and analgesic consumption

	Group T (n=30)	Group I (n=30)	p-value
NRS			
0	3 (4)	5 (5)	**<0.001**
2	3 (2)	3 (3)	**0.035**
4	2 (2)	3 (2)	**<0.001**
8	2 (2)	2 (2)	0.998
12	1 (3)	2 (2)	0.799
24	1 (2)	1 (2)	0.998
Rescue time (minute)	135.83±30.45	91.67±27.92	**<0.001**
Rescue analgesic consumption (Dexketoprofen, mg)	58.33±18.95	76.66±31.44	**0.009**

p<0.05 was considered significant
NRS: Numerical rating scale

the TAP block, when combined with general anaesthesia, effectively mitigates oxidative damage caused by surgical trauma. Acute pain resulting from surgical trauma induces a neuroendocrine stress response, leading to increased sympathetic activity, inflammation, and oxidative stress (14,19). It has been reported that poorly managed postoperative pain is associated with elevated oxidative stress (20). In patients who received a TAP block, lower pain scores observed in the early postoperative period suggest a more effective attenuation of the neuroendocrine stress response to surgery, which we believe contributed to the lower levels of oxidative stress.

Enhanced recovery after surgery (ERAS) protocols are evidence-based, multidisciplinary care pathways developed to accelerate postoperative recovery. Key components such as early mobilization, opioid-sparing analgesia, and attenuation of the inflammatory and oxidative stress responses to surgical trauma aim to reduce complications (21). Increased oxidative stress has been associated with a higher risk of infections, delayed wound healing, pulmonary complications such as acute respiratory distress syndrome, acute kidney injury, and postoperative delirium (22). Lower oxidative stress levels in patients undergoing oesophageal surgery have been associated with fewer postoperative complications and shorter hospital stays (23). Furthermore, the role of oxidative stress in the pathophysiology of sepsis has been well documented (24). Given these associations, we believe it is crucial to explore treatment strategies aimed at reducing oxidative stress.

Both TAP block and local anesthetic infiltration are commonly used techniques with proven analgesic efficacy in abdominal surgeries. The use of both methods is recommended within ERAS protocols as part of a multimodal analgesic approach (21). Several studies in the literature have reported comparable analgesic efficacy between TAP block and local anesthetic infiltration (25,26) Grape et al. (27) reported in a meta-analysis that TAP block provides superior analgesic efficacy compared with local anesthetic infiltration. Additionally, in a study involving patients undergoing laparoscopic gastric bypass surgery, the TAP block was associated with lower pain scores, reduced opioid consumption, and shorter hospital stays compared with trocar-site infiltration (28). In this study, patients who received the TAP block demonstrated lower pain scores and required less rescue analgesia at 0, 2, and 4 hours postoperatively. We believe that the similarity in pain scores at later time points may be attributable to the use of additional analgesics by patients who did not receive the TAP block. Although the literature reports conflicting results regarding the analgesic efficacy of TAP block versus trocar site infiltration, our findings suggest that TAP block provides superior analgesia compared with trocar site infiltration.

Study Limitations

This study has some limitations. First, we did not assess oxidative stress levels or pain scores beyond the 24-hour postoperative period. Consequently, we were unable to evaluate the long-term effects of oxidative stress and pain, including potential postoperative complications attributable to the former. Another limitation was that only patients who underwent surgery performed by a single surgical team using a single technique were included in the study, thereby precluding evaluation of other surgical techniques.

CONCLUSION

We found that the combination of TAP block with general anaesthesia effectively reduced both oxidative stress and postoperative pain. We believe that optimal management of postoperative pain reduces oxidative stress levels. Furthermore, we suggest that oxidative stress be further investigated across various surgical procedures and anaesthesia techniques.

ETHICS

Ethics Committee Approval: This single-centre, randomised controlled study complied with the ethical standards of the Declaration of Helsinki. Approval for the study was obtained from the Ethics Committee of University of Health Sciences Türkiye, Ankara Etlik City Hospital No. 1 Clinical Research (approval no: 037, date: 05.04.2023).

Informed Consent: Written informed consent was obtained from all the participants.

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: Y.Ö., S.A., G.K., J.E., C.H., İ.Ö., Concept: Y.Ö., S.A., G.K., J.E., İ.Ö., G.O., Ö.E., Design: Y.Ö., S.A., G.K., C.H., İ.Ö., G.O., Ö.E., Data Collection or Processing: Y.Ö., J.E., C.H., İ.Ö., G.O., Ö.E., Analysis or Interpretation: Y.Ö., G.K., J.E., İ.Ö., G.O., Ö.E., Literature Search: Y.Ö., S.A., G.K., C.H., İ.Ö., Writing: Y.Ö., S.A., G.K., J.E., C.H., G.O.

Conflict of Interest: No conflict of interest was declared by the authors.

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