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Evaluation of the Relationship Between Intraoperative Cerebral Oxygen Saturation and Postoperative Cognitive Functions in Laparoscopic Hysterectomy Surgery

Laparaskopik Histerektomi Cerrahisinde İntraoperatif Serebral Oksijen Saturasyonu ile Postoperatif Kognitif Fonksiyonların İlişkisinin Değerlendirilmesi

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Abstract

Aim: Laparoscopic surgery has become more popular than traditional open surgery because it is less invasive, provides faster recovery, and provides better cosmetic success. This procedure requires insufflation of an inert gas into the peritoneal cavity. This may be an increase in arterial carbon dioxide pressure, changes in cerebral blood flow, an increase in intra-abdominal pressure (IAP), a decrease in cardiac output. The primary outcome of this study is to show the effect of IAP levels on cerebral oxygen saturation (COS) in patients who underwent total laparoscopic abdominal hysterectomy (TLH), and the secondary outcome is to reveal the relationship between IAP and COS and the recovery of postoperative cognitive functions.

Material and Method: Demographic data of the cases were recorded and mini-mental test (MMT) was applied to evaluate the preoperative cognitive functions of the cases before surgery. COS monitoring were performed with standard anesthesia procedure for all patients. The MMT was repeated 30 minutes after the operation.

Results: A total of 40 female patients were included in the study. Those with IAP level 12 mmHg and below were defined as Group Low-Pressure, and those above 12 mmHg were defined as Group High-Pressure. There was no statistical difference between the anesthesia times and recovery times of the two groups. While there was no statistical difference in the preoperative MMT evaluation, it was found to be significantly lower in Group H in the postoperative MMT evaluation.

Conclusion: In this study, we evaluated the effect of intraoperative IAP levels on intraoperative COS. It is seen that high IAP level does not have a negative effect on COS. In addition, this study has evidence that high IAP affects postoperative cognitive functions. In intraoperative management for TLH surgery, we recommend maintaining the IAP level at the lowest appropriate pressure that does not impair surgical comfort.

Keywords: Cerebral oxygen saturation, cognitive functions, laparoscopic hysterectomy, general anesthesia

Öz

Amaç: Laparoskopik cerrahi, daha az invaziv olması, daha hızlı iyileşme sağlaması ve daha iyi kozmetik başarı sağlaması nedeniyle geleneksel açık cerrahiden daha popüler hale gelmiştir. Bu prosedür, inert bir gazın periton boşluğuna üflenmesini gerektirir. Karın içersine gaz insuflasyonu, arteriyel karbondioksit basıncında bir artış, serebral kan akışında değişiklikler, intraabdominal basınçta (İAB) bir artış, kalp debisinde azalmaya neden olabilir. Bu çalışmanın birincil sonucu, total laparoskopik abdominal histerektomi (TLH) uygulanan hastalarda İAB düzeylerinin serebral oksijen satürasyonu (SOS) üzerindeki etkisini göstermek ve ikincil sonuç, İAB ve SOS ile postoperatif bilişsel işlevlerin iyileşmesi arasındaki ilişkiyi ortaya koymaktır.

Gereç ve Yöntem: Olguların demografik verileri kaydedildi ve olgulara ameliyat öncesi kognitif fonksiyonlarını değerlendirmek için ameliyat öncesi mini-mental test (MMT) uygulandı. Tüm hastalar için standart anestezi prosedürü ile SOS monitörizasyonu yapıldı. MMT ameliyattan 30 dakika sonra tekrarlandı.

Bulgular: Çalışmaya toplam 40 kadın hasta dahil edildi. İAB seviyesi 12 mmHg ve altında olanlar Grup Düşük-Basınç (Grup L), 12 mmHg'nin üzerinde olanlar Grup Yüksek-Basınç (Grup H) olarak tanımlandı. İki grubun anestezi süreleri ve derlenme süreleri arasında istatistiksel fark yoktu. Preoperatif MMT değerlendirmesinde istatistiksel olarak fark bulunmazken, postoperatif MMT değerlendirmesinde Grup H'de anlamlı olarak düşük bulundu.

Sonuç: Yüksek İAB düzeyinin SOS'a olumsuz etkisinin olmadığı görüldü. Ayrıca bu çalışmada yüksek İAB'nin ameliyat sonrası kognitif fonksiyonları etkilediğine dair kanıtlar var. TLH cerrahisi için intraoperatif yönetimde, İAB seviyesinin cerrahi konforu bozmayan uygun en düşük basınçta tutulmasını öneririz.

Anahtar Kelimeler: Serebral oksijen saturasyonu, kognitif fonksiyonlar, laparaskopik histerektomi, genel anestezi

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INTRODUCTION

Laparoscopic surgery has become more popular than traditional open surgery because it is less invasive, provides faster recovery, and provides better cosmetic success. This procedure requires insufflation of an inert gas into the peritoneal cavity. Often this gas is carbon dioxide (CO_2). Although CO_2 is used, which is optimal for insufflation, there may be an increase in arterial CO_2 ($PaCO_2$) and changes in cerebral blood flow. In addition, peritoneal insufflation leads to an increase in intra-abdominal pressure (IAP), which leads to a decrease in cardiac output.[1]

Atelectasis may develop due to the effect of pneumoperitoneum and oxygenation may be affected, therefore it is recommended to apply prophylactic positive end-expiratory pressure (PEEP) intraoperatively to patients. Since standard monitoring may not be sufficient to determine the conditions in which cerebral oxygenation is affected, monitors such as cerebral oximetry (SO_2) by near-infrared spectroscopy (NIRS), which are used to measure SO_2, have been used in recent times. Thanks to NIRS, if cerebral oxygenation is adversely affected, it can be detected early and before tissue hypoxia occurs.[2-5]

In the literature, the number of studies using NIRS in gynaecological laparoscopy surgeries with Trendelenburg and pneumoperitoneum is limited, and no study evaluating its relationship with intra-abdominal pressure has been found.

The primary outcome of this study is to show the effect of intra-abdominal pressure levels on cerebral oxygenation in patients who underwent total laparoscopic hysterectomy (TLH), and the secondary outcome is to reveal the relationship between IAP and cerebral oxygen saturation (COS) and the recovery of postoperative cognitive functions.

MATERIAL AND METHOD

Study designed as a prospective and observational. The study was carried out with the permission of Necmettin Erbakan University Ethics Committee (Date: 16.04.2021, Decision No: 2021/3209). The study was carried out in accordance with the Declaration of Helsinki, in the gynaecology operating room of our hospital, between January and June 2022. Among the patients who will undergo total hysterectomy surgery with the laparoscopic approach, 40 patients whose physical status is 'I' or 'II' according to the American Society of Anesthesiology (ASA) classification, aged 18-65 years, and whose informed consent was obtained, were included in the study.

Cases with disorientation and cooperation disorders, cases with severe psychiatric disorders, emergency cases, cases with cardiac dysrhythmia and a history of heart failure, cases with drug dependence, cases who needed intraoperative inotropic drug use, and cases who refused to volunteer were excluded from the study. Demographic data of the cases were recorded and mini-mental test was applied to evaluate the preoperative cognitive functions of the cases before surgery.

Electrocardiography (ECG), noninvasive arterial blood pressure measurement, pulse oximetry (SpO_2), Train of Four (TOF) with neuromuscular transmission and NIRS monitoring were performed as standard anesthesia procedure for all patients. All patients were given 0.15 mg/kg midazolam, 2 mg/kg propofol induction, 0.2 mcg/kg/min remifentanil infusion and 0.6 mg/kg rocuronium muscle relaxation. Intubation was performed when the TOF ratio reached zero. For maintenance anesthesia, 0.5-1 MAC sevoflurane and 0.2 mcg/kg/min remifentanil were used.

After obtaining abdominal access for insufflation, a 300-degree trendelenburg position was given. IAP was increased to the level that the surgical area could be adequately visualized (min 8-max 14). IAP level 12 and below were defined as Group Low-Pressure (Group L), and those above 12 were defined as Group High-Pressure (Group H).

Hemodynamic data was recorded throughout the operation. Tramadol 2 mg/kg for postoperative analgesia and ondansetron 4 mg for nausea were administered.

At the end of the surgery, the maintenance of anesthesia was terminated and the patient was awakened. The time from anesthesia induction to extubation was recorded as the duration of anesthesia. The patient was taken to the recovery unit and followed up until the Aldrete score reached 9. The time from extubation to an Aldrete score of 9 was recorded as recovery time.

The mini-mental test was repeated 30 minutes after the end of the operation to evaluate the cognitive functions.

Statistical Analysis

SPSS 18.00 (Statistical Package for Social Sciences, Inc., Chicago, IL) program was used for the analysis of the collected data. Obtained continuous variables were expressed as mean±SD or number (%). Number and % values were used in the presentation of categorical variables. The conformity of the obtained data to the normal distribution was evaluated using the "Kolmogorov-Smirnov test". The "Mann-Whitney-U" test was used in the analysis of continuous variables (age, weight, etc.). Chi-square test was used to compare two groups and to analyse categorical variables. A p value of <0.05 was considered significant in the analyses.

RESULTS

A total of 40 female patients were included in the study. The age, height and weight values of the groups were examined, there was no statistical difference (**Table 1**). The ASA distributions of the groups were also similar (**Table 2**).

Table 1: ASA distributions of the groups

		Group L	Group H	Total	P value
ASA	I	5	7	12	0.529
	II	13	15	28	
Total		18	22	40	

ASA: American Society of Anesthesiology classification, Group L: Intra Abdominal Pressure level 12 mmHg and below, Group H: Intra Abdominal Pressure above 12 mmHg

Table 2: Age, height and weight values of the groups

	Group L	Group H	P Value
Age	48.89±10.00	50.46±8.27	0.591
Height	163.61±5.41	163.59±6.10	0.991
Weight	75.00±7.52	73.27±17.99	0.706

Group L: Intra Abdominal Pressure level 12 mmHg and below, Group H: Intra Abdominal Pressure above 12 mmHg

In intraoperative hemodynamic follow-up, heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) were compared between the groups and there was no statistical difference (**Table 3**). NIRS monitoring findings were similar (**Table 4**).

There was no statistical difference between the anesthesia times and recovery times of the two groups (**Table 5**).

Table 5: Comparison of the anesthesia and recovery times of the groups

	Group L	Group H	P Value
Anesthesia Duration (min)	75.00±21.83	77.05±21.36	0.767
Recovery Duration (min)	20.56±12.47	17.50±7.52	0.344

Group L: Intra Abdominal Pressure level 12 mmHg and below, Group H: Intra Abdominal Pressure above 12 mmHg

While there was no statistical difference in the preoperative mini-mental test (MMT) evaluation, it was found to be significantly lower in Group H in the postoperative MMT evaluation (**Table 6**).

Table 6: Comparison of the MMT scores of the groups

	Preoperative-MMT	Postoperative-MMT	P Value
Group L	23.61±3.17	21.89±2.27	0.055
Group H	23.18±3.23	19.46±3.32	0.001*

MMT: Mini Mental Test, Group L: Intra Abdominal Pressure level 12 mmHg and below, Group H: Intra Abdominal Pressure above 12 mmHg

DISCUSSION

In this study, we evaluated the effect of intraoperative IAP levels on intraoperative COS. Our findings show that there is no difference between the IAP levels oxygen saturation with NIRS monitoring. While no difference was observed in terms of recovery after anesthesia, a negative effect of high pressure level on postoperative cognitive functions was determined.

Conditions such as advanced age, bleeding-transfusion, major orthopedic traumas, prolonged surgeries, infection, and pulmonary complications in the perioperative period may increase the risk of cognitive dysfunction.[6,7] Additionally, intraoperative cerebral oxygen desaturation has been found to be associated with cognitive dysfunction and prolonged hospitalization.[8] When this study was designed, patients with advanced age, transfusion status, and perioperative complications were not included in the study. In a study in which only the early period was evaluated, the researchers reported that postoperative cognitive dysfunction (POCD)

Table 3: Comparison of hemodynamic values of the groups

	Heart Rate			Systolic Blood Pressure			Diastolic Blood Pressure		
	Group L	Group H	P Value	Group L	Group H	P Value	Group L	Group H	P Value
Basic	83.61±17.93	80.87±14.53	0.421	143.22±18.53	136.96±15.48	0.710	83.39±7.86	80.68±8.71	0.763
3.min intubation	69.83±15.32	71.96±13.51	0.914	99.6±19.20	104.82±17.57	0.445	55.28±13.91	60.59±12.32	0.503
5.min TP	61.56±10.26	64.00±9.06	0.415	107.44±15.40	108.18±15.12	0.718	62.33±10.27	61.32±13.90	0.465
15.min TP	63.94±8.74	63.60±7.60	0.200	107.78±12.52	112.32±14.99	0.204	63.83±6.7	63.36±11.16	0.044
30.min TP	63.83±9.24	64.05±11.26	0.522	110.00±±13.08	108.55±±16.27	0.162	64.83±9.22	59.96±12.87	0.074
45.min TP	65.67±10.49	64.36±9.467	0.513	109.28±14.43	112.64±17.42	0.502	62.83±9.22	62.14±14.54	0.138
60.min TP	63.06±11.78	63.50±9.23	0.502	103.56±13.37	104.46±16.22	0.545	59.00±8.70	59.23±12.62	0.243
Position	59.78±12.98	62.55±11.51	0.874	101.94±16.2	99.27±18.12	0.819	57.83±10.02	54.46±12.58	0.493
End Of Operation	86.39±17.72	88.14±13.33	0.101	125.89±19.99	119.68±20.56	0.988	75.06±13.06	71.14±14.66	0.278

RTP: 300 Trendelenburg Position, Group L: Intra Abdominal Pressure level 12 mmHg and below, Group H: Intra Abdominal Pressure above 12 mmHg

Table 4: Comparison of NIRS values of the groups

	Right Cerebral Oxygen Saturation			Left Cerebral Oxygen Saturation		
	Group L	Group H	P Value	Group L	Group H	P Value
Basic	67.06±7.35	62.23±6.38	0.669	65.61±6.75	62.96±6.13	0.652
3.min intubation	70.61±9.48	65.55±8.59	0.311	69.11±10.74	66.09±9.60	0.337
5.min TP	66.83±8.33	66.96±8.87	0.799	64.11±8.51	65.64±7.80	0.502
15.min TP	73.33±7.59	70.59±8.23	0.911	71.44±8.57	67.77±8.76	0.900
30.min TP	71.67±7.55	68.09±9.58	0.730	70.50±9.15	65.87±9.40	0.819
45.min TP	73.33±7.59	66.73±10.08	0.419	71.44±8.57	67.32±9.16	0.691
60.min TP	70.33±7.72	65.41±8.62	0.951	68.44±8.76	66.68±10.20	0.660
Position	70.22±8.60	64.91±8.09	0.603	67.06±8.54	64.27±8.36	0.625
End Of Operation	73.56±9.65	71.46±9.20	0.435	72.56±9.49	70.41±10.73	0.680

RTP: 300 Trendelenburg Position Group L: Intra Abdominal Pressure level 12 mmHg and below Group H: Intra Abdominal Pressure above 12 mmHg

was detected in one third of the patients at the postoperative 3rd hour, and this situation improved after 24 hours.[9] It is recommended to perform early postoperative cognitive function evaluation within the first week.[6,7] Considering this recommendation, cognitive function evaluation was performed on the operation day.

Hemodynamics may be adversely affected due to pneumoperitoneum. Bradycardia with vagal reflex due to pneumoperitoneum has been reported, especially during insufflation. This bradycardia was treatable with atropine. Cardiac arrest developed in resistant cases. Cerebral oxygenation monitoring values performed in bariatric surgeries are not affected by hemodynamic changes, and hemodynamic changes are generally well tolerated in terms of cerebral perfusion.[10] No statistically significant finding was obtained in a study evaluating the effect of hemodynamic events on cerebral oxygenation.[11] Consistent with the literature, no hemodynamic changes requiring medical intervention were recorded in cerebral oxygenation values. In addition, despite the difference in intra-abdominal pressure, no statistically significant difference was observed between the groups in terms of hemodynamics.

It has been reported that trendelenburg position and carbon dioxide pneumoperitoneum increase intracranial pressure (ICP)[12,13] and change cerebral blood flow (CBF) or volume (CBV).[14,15] Therefore, gynaecological laparoscopic surgery may affect brain oxygenation by altering cerebral hemodynamics. The head-down position causes an increase in ICP, CBF, and CBV[16,17] and a decrease in carotid artery blood flow.[18,19] All of these factors may impair cerebral tissue oxygenation by decreasing cerebral perfusion pressure.[20]

Intracranial, intrathoracic and intraabdominal compartment pressures are interrelated. They concluded that neurologic follow-up should include minimizing intrathoracic and intra-abdominal pressures as much as clinically possible, as well as ICP control.[21] Another indication of the link between cerebral venous outflow and ICP is the beneficial effect of raising the head of the bed in lowering ICP.[22]

The first well-conducted clinical study evaluating the relationship between IAP and ICP was published in 2001 by Citerio et al. They conducted a prospective, nonrandomized observational study that systematically measured the effect of increased IAP by placing a 15 L soft water bag on the patient's abdomen. The authors found that weight bearing on the patient's abdomen resulted in a significant increase in IAP, accompanied by a rapid increase in ICP, central venous pressure (CVP), and jugular bulb pressure (IJP).[23]

Ventilation maneuvers to treat respiratory failure (e.g., recruitment) may increase intrathoracic pressure, limit venous return, and thereby increase ICP and decrease cerebral perfusion pressure.[22]

Available information indicates that there are two pathways by which IAP can be delivered to the central nervous system. First, the reflux flow from the venous plexus of the spinal canal and intracranial veins. The valveless nature of the venous plexus provides a direct anatomical route from the pelvis to the eyes and brain. This is a pathway involving multiple anastomoses to the systemic venous circulation, including the venous circulation of the lungs, renal veins, and thoracic veins. The second pathway is a direct effect through an increase in IAP causing cranial extension of the diaphragm. Increased intrathoracic pressure and increased central venous pressure causes decreased venous drainage from the central nervous system via the jugular system.[24]

Intra-abdominal hypertension (IAH) is usually determined by three consecutive measurements taken at 4-to-6 hour intervals and is defined as 12 mmHg or higher.[25] Based on this information, patients with IAP values above 12 were considered high pressure, and patients with IAP values below 12 were considered low pressure and were divided into two groups.

Intraoperative cerebral hypoperfusion and desaturation are important factors in the development of neurological complications, and cerebral monitoring is known to provide significant benefits in determining this. With the use of NIRS, low regional COS has been shown to be associated with neurological complications and cognitive impairment.[26,27] NIRS monitoring was applied to all patients included in the study and there was no finding that required intervention during monitoring. In addition, the groups were similar in terms of duration of anesthesia and recovery times. However, a difference was observed in the cognitive assessment of patients exposed to different IAP. We believe that this is due to the increase in intracranial pressure due to high IAP.

In the light of this information, we believe that the negative movement in cognitive functions in the group with high intra-abdominal pressure in our study is due to the deterioration of cerebral venous return due to high intra-abdominal pressure, the increase in central venous pressures and the increase in intracranial pressure.

This study has several limitations. Initially, only patients aged 19 to 65 years with ASA physical status 1 or 2 were included in the study. Considering the physiological and pathological changes in the elderly population, worse outcomes may be seen. Secondly, as long as patients are normocapnic, pneumoperitoneum has no effect on cerebral oxygenation. On the other hand, cerebral oxygenation is impaired when hypercapnic.[28] In our study, while carbon dioxide monitoring was not performed, no deterioration in cerebral oxygenation occurred in any of the patients. Finally, although the patient was treated to provide pain control during postoperative care, the data of the patients for this period were not examined.

CONCLUSION

In this study, it is seen that high intra-abdominal pressure level does not have a negative effect on cerebral oxygenation. In addition, this study has evidence that high IAP negatively affects postoperative cognitive functions. In intraoperative

management for TLH surgery, we recommend maintaining the IAP level at the lowest appropriate pressure that does not impair surgical comfort.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Necmettin Erbakan University Ethics Committee (Date: 16.04.2021, Decision No: 2021/3209).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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