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Changes in cerebral oxygen saturation with the Trendelenburg position and increased intraabdominal pressure in laparocopic rectal surgery

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ABSTRACT

Objective: Position changes and increased intra-abdominal pressure in laparoscopic interventions lead to some physiopathological changes. There is no definite information in the literature regarding cerebral oxygen saturation in patients undergoing colorectal surgery. Our aim was to investigate whether there is oxygen saturation change in the brain tissue in pneumoperitoneum and the Trendelenburg position during laparoscopic rectal surgery.

Material and Methods: Cerebral oxygen saturation was measured in 35 patients who underwent laparoscopic rectal surgery in the Trendelenburg position. Measurements were made under general anesthesia in the pneumoperitoneum and the Trendelenburg position.

Results: The values that are statistically affected by the position are systolic blood pressure, mean arterial blood pressure and cerebral oxygen saturation. The Trendelenburg position does not disturb the cerebral oxygen saturation and it causes an increase in saturation. After pneumoperitoneum occurred, changes in systolic blood pressure, mean arterial blood pressure and brain oxygen saturation were detected. Cerebral oxygen saturation increases with the formation of pneumoperitoneum.

Conclusion: The Trendelenburg position and increased intraabdominal pressure during laparoscopic rectal surgery do not impair brain oxygen saturation.

Keywords: Laparoscopy, Trendelenburg position, brain oxygen saturation

INTRODUCTION

Laparoscopic surgery causes less damage to functional tissues than open surgery. Increased intraabdominal pressure puts pressure on venous vessels, reducing bleeding and the need for blood transfusion. Detailed anatomical imaging provided by optical magnification allows for successful surgical dissection. In the postoperative period, patients have less pain and analgesic requirements (1,2). Despite all of its advantages, it is compared to open surgery due to its disadvantages such as long operation time, unique complications and high cost. Although the discussions on this issue have decreased, they still continue. The rate of serious complications in laparoscopic surgery is low (1). It is known that positional changes, increased intra-abdominal pressure, and carbon dioxide (CO_2) insufflation in laparoscopic interventions cause some physiopathological changes (2). The results of studies on their hemodynamic effects in laparoscopic surgery are not compatible with each other. During laparoscopy, many factors, including general anesthesia, position, increased intraabdominal pressure and the patient's cardiac state, affect hemodynamics (3).

In laparoscopic surgery, depending on the type of operation, an upside down or head-up position is given to move the organs with the effect of gravity. These positions can cause unwanted hemodynamic changes. The changes in intracranial pressure and cerebral oxygen saturation ($bSaO_2$) that occur during this time have not been discussed much in the literature (4-6). In laparoscopic colorectal surgery, intraabdominal CO_2 gas is inflated to create a visual field. Hemodynamic changes occur due to intraabdominal pressure. Laparoscopic rectal surgery is in the Trendelenburg position and takes hours depending on the size of the surgery.

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Meanwhile, intracranial venous congestion takes place. Macroscopically, swelling and discoloration occur on the patient's face, eyelid and neck. Our aim was to investigate whether there is an oxygen saturation change in the brain tissue in the pneumoperitoneum and the Trendelenburg position during laparoscopic rectal surgery.

MATERIAL and METHODS

The study was carried out prospectively in Necmettin Erbakan University Meram Medical Faculty of Medicine between January 2019 and January 2020 with the approval of the ethics committee (2018/1601). Thirty-five consecutive patients who underwent laparoscopic rectal surgery in the Trendelenburg position were included in the study. Patients who did not want to be included in the study, who were decided to have open surgery due to complications during laparoscopic rectal surgery, who had a hematocrit value below 30, who had morbid obesity, and major bleeding during surgery were excluded from the study. Surgery of all patients was performed by the same surgical team. According to the ASA score used by the American Anesthesiologists Association, ASA 2-3 patients were operated under elective conditions. All participants gave their written informed consent after the researchers explained the aim and course of the study. Verbal consent was also obtained from all participants.

The patients were taken to the operating room after a six-hour fasting period. The same general anesthesia method was applied to all patients, and operation was performed by the same surgical team. Electrocardiogram, peripheral oxygen saturation, non-invasive blood pressure measurement and muscle relaxant monitoring with neuromuscular transducer (NMT) were performed in the operating room. Crystalloid infusion at a dose of 15 mL/kg/h was initiated by providing an iv route with a 22 gauge intracet. Patients were sedated with 0.03 mg/kg midazolam (Midolam®, Mefar, İstanbul, Türkiye). For anesthesia induction, 40 mg lidocaine (Jetmonal®, Adeka, Samsun, Türkiye), 2 mg/kg propofol (Propofol 1% Fresenius®, Kabi Fresenius AB, Uppsala, Sweden), 1 µg/kg remifentanil (Rentanil®, VEM, Ankara, Türkiye) and 0.6 mg/kg rocuronium (Myocron® VEM, Ankara, Türkiye) were administered. Patients were intubated while train of four (TOF) was 0%. The anesthesia was maintained by 30-50% FiO_2, 0.5-1 MAC desflurane (Suprane®, Baxter Healthcare, Puerto Rico, USA) inhalation and remifentanil infusion, with SpO_2 being 96-98%. During surgery, analgesic requirement of the patients was monitored using the surgical plethysmographic index (SPI), and the remifentanil infusion dose was adjusted so that the SPI was below 50. For ventilation, tidal volume was 6 mL/kg, respectively, and the frequency was set as end tidal CO_2 30-35 cm H_2O.

Nasopharyngeal temperature of the patients was adjusted to be 36-36.5 C°. Nasogastric tube and urinary catheter were placed in all patients. Invasive arterial monitoring and central vascular access were established in patients when deemed necessary. The first trocar was placed under the umbilical line by direct method. After the endo-camera control, pneumoperitoneum was created and intraabdominal pressure was kept between 10-14 mmHg. Other trocars were placed visually in the endo-camera. The patients were operated in a 30-degree Trandelenburg position.

Brain oxygen saturation was measured with a near infrared spectroscopy device (INVOS™ 5100C Cerebral/Somatic Oximeter, Medtronic, Minneapolis, USA). Cerebral SaO_2 saturation was measured from the right and left cerebral hemispheres with a catheter placed in the patient's frontal region (noninvasive). Measurements were performed consecutively under general anesthesia before the pneumoperitoneum, after the pneumoperitoneum was formed and after the pneumoperitoneum was terminated. Before, during and after the Trendelenburg position, serial measurements were made, and the results were recorded. The position and pneumoperitoneum values were compared independently in the study. Following the creation of the pneumoperitoneum, it was measured after waiting 10 minutes, then position measurement values were taken after positioning. In surgeries lasting one hour or longer, measurements were repeated every hour.

Parameters examined were age, sex, tumor location, surgery performed, intraabdominal pressure, operation time, pneumoperitoneum duration, ASA score, pulse, systolic arterial pressure (SAP), mean arterial pressure (MAP), peripheral oxygen saturation (SaO_2), right cerebral oxygen saturation ($bSaO_2$), left cerebral $bSaO_2$ and fraction of inspired oxygen (FiO_2).

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-Wilk tests were used to control the distribution of the parameters. Whether there was a statistically significant difference between recurrent systolic blood pressure, mean arterial pressure, heart rate, FiO_2, SO_2, right and left brain oxygen saturation measurements in the patients was determined by repeated measured variance analysis. If this result was found to be significant, the measurement times that caused a significant difference were determined with the Bonferroni corrected multiple comparison test. In cases where the result of Friedman test statistics was significant, measurement times that caused the difference were determined using the Bonferroni corrected Wilcoxon sign test. In the interpretation of statistical hypothesis tests, type 1 error was accepted as 0.05. The collected data were analyzed by SPSS program.

RESULTS

Thirty-five patients, seven females and 28 males, with a mean age of 63.71 years (50-84), were included in the study. All of the patients had been operated for rectal cancer. Six patients underwent anterior resection and 29 patients underwent low anterior

Table 1. Demographic and operative information		
		n= (35)
Sex (n)	Female	7 (20%)
	Male	28 (80%)
ASA score (n)	ASA 2	26 (74.3%)
	ASA3	9 (25.7%)
		Mean ± SD
Age		63.71 ± 8.79
Intraabdominal pressure		12.64 ± 0.8
Operation duration (minutes)		153.71 ± 33.57
Pneumoperitoneum time (minutes)		102.09 ± 24.31
Major intraoperetive complication		0
ASA: American Society of Anesthesiologists.		

resection. According to the evaluation of anesthesia, the ASA score was three in nine of the cases and two in 26 cases. No major complications developed in any of the patients during the operation. Intraabdominal pressure was on average 12.64 (12-14) mmHg. The operation time was 153.71 minutes (90-220) and pneumoperitoneum time was 102.09 minutes (70-150) (Table 1).

Change in parameters according to the Trendelenburg position (Table 2)

The values that are statistically affected by the position are systolic blood pressure, mean arterial blood pressure and brain oxygen saturation. SAP and MAP increase with the Trendelenburg position. However, this increase was not statistically significant. After correction of the position, there is a serious decrease in SAP and MAP pressure ($p< 0.001$). Blood pressure cannot reach the baseline value after correcting the Trendelenburg position ($p< 0.001$). It can reach normal values in the postoperative recovery room. Increased cerebral oxygen saturation was found with the Trendelenburg position ($p< 0.001$). The Trendelenburg position does not disturb the brain oxygen saturation and causes an increase in saturation. Pulse peripheral SaO_2 and FiO_2 change were not affected by the position. We found a minimal decrease in heart rate due to the position, but this was not statistically significant.

Change in parameters according to pneumoperitoneum status (Table 3)

It was seen that some increase in the heart rate occurs after pneumoperitoneum. However, we detected some decrease in

Table 2. Change in parameters according to surgical position change

	Before position	**During position**	**After position**	**p***
Pulse	69.9 ± 10.4	66.3 ± 10.8	65.2 ± 9.1	0.3
SAP	122.5 ± 24.4^a	127.3 ± 18.3^b	107.1 ± 14^c	<0.001$^{(a-c), (b-c)}$
MAP	91.7 ± 19.1^a	94 ± 10.9^b	76.3 ± 10^c	<0.001$^{(a-c), (b-c)}$
SaO_2	97.9 ± 1.5	97.5 ± 1.7	98.5 ± 1.2	0.17
Right $bSaO_2$	64.6 ± 7.2^a	67.4 ± 8^b	69.5 ± 7.8^c	<0.001$^{(a-b), (a-c)}$
Left $bSaO_2$	65.7 ± 8.4^a	67.5 ± 8.5^b	68.2 ± 9.8^c	<0.001$^{(a-b), (a-c)}$
FiO_2	82.5 ± 14.2	46.7 ± 6.8	56.2 ± 19.2	0.17

SAP: Systolic arterial pressure, MAP: Mean arterial pressure, SaO_2: Oxygen saturation, $bSaO_2$: Cerebral oxygen saturation, FiO_2: Fraction of inspired oxygen.
Pulse, SaO_2 and FiO_2 values of the patient are given in the table. Values resulting in $p< 0.05$ are presented.
*The columns between the calculated p values are shown with upper symbols.

Table 3. Change in parameters according to the pneumoperitoneum status

	Before pneumoperitoneum	**During pneumoperitoneum**	**After pneumoperitoneum**	**p***
Pulse	66.2 ± 11.9	67.1 ± 11.5	65 ± 8.2	0.24
SAP	102.7 ± 25.1^a	122.3 ± 27.8^b	110.3 ± 19.1^c	<0.001$^{(a-b), (b-c)}$
MAP	70.2 ± 10.7^a	87.9 ± 17.3^b	78.6 ± 10.6^c	<0.001$^{(a-b), (a-c), (b-c)}$
SaO_2	98.4 ± 1.7	98.6 ± 0.9	98.5 ± 1.1	0.53
Right Brain SaO_2	61.5 ± 8.6^a	64.1 ± 8^b	70.2 ± 6.7^c	<0.001$^{(a-b), (a-c), (b-c)}$
Left Brain SaO_2	64.3 ± 8.8^a	65 ± 8.4^b	69.4 ± 8.1^c	<0.001$^{(a-c), (b-c)}$
FiO_2	46.6 ± 8.3	44.9 ± 6.6	49.4 ± 14.3	0.13

SAP: Systolic arterial pressure, MAP: Mean arterial pressure, SaO_2: Oxygen saturation, $bSaO_2$: Cerebral oxygen saturation, FiO_2: Fraction of inspired oxygen.
Pulse, SaO_2 and FiO_2 values of the patient are given in the table. Values resulting in $p< 0.05$ are presented.
*The columns between the calculated p values are shown with upper symbols.

the end of the pneumoperitoneum ($p > 0.24$). As with the change of position, the parameters most affected by the pneumoperitoneum were systolic blood pressure, mean arterial blood pressure and brain oxygen saturation. SAP and MAP increase with pneumoperitoneum and decrease after the pneumoperitoneum, but remain higher than the baseline value ($p < 0.001$). It can reach normal values in the postoperative recovery room. Increased cerebral oxygen saturation was detected with the formation of the pneumoperitoneum ($p < 0.001$). Pneumoperitoneum did not impair cerebral oxygen saturation. However, there are differences in the right and left hemispheres of the brain. Brain oxygenation in the right half of the brain is better at the end of the pneumoperitoneum. However, left brain oxygenation baseline value was found to be better than the right. The change in pulse SaO_2 and FiO_2 was not affected by position.

DISCUSSION

A pneumoperitoneum is created for laparoscopic surgery. Pneumoperitoneum is done by CO_2 insufflation. Studies have been conducted to reveal the effects of increased intraabdominal pressure. Cardiopulmonary and renal effects have been examined in most of these studies (2). When intraabdominal pressure increases during laparoscopic surgery, there is a decrease in cardiac performance. Hypercapnia in the pneumoperitoneum increases the incidence of cardiac arrhythmias. However, information about its effect in the intracranial area is limited. This limited information has generally been obtained from the colorectal non- surgical field. In our study, it was found that SAP and MAP increase with pneumoperitoneum and decrease after the pneumoperitoneum, but higher than the basal value ($p < 0.001$). We found that cerebral oxygen saturation increased with the formation of pneumoperitoneum ($p < 0.001$).

There are few studies on the effects and complications of laparoscopic surgery position. In these publications, findings about the prolonged Trendelenburg position are presented. However, almost all of these works have been obtained from gynecological and urological surgeries (2). Data on colorectal laparoscopic surgery are limited. The effect of the prolonged Trendelenburg position on the brain has not been fully studied. In particular, there is no definitive data on the change in cerebral oxygen saturation. This issue has been tried to be enlightened in our study. Cardiovascular and pulmonary effects occur rapidly with the Trendelenburg position. However, its effects on the brain appear more slowly (2). An increase in venous return to the heart is observed with the Trendelenburg position. The most important effect of this increase is gravity. With the effect of increased venous transformation, an increase in arterial pressure and central venous pressure is observed (7,8). An increase of 53-125% in central venous pressure, 15% and 35% in mean arterial pressure is observed. In our study, MAP increased by 25.2%. Most of the studies have problems regarding sex distribution. Studies consist of either the female gender sex to gynecological surgery work or the male sex due to prostatectomy surgery. Therefore, the studies do not provide a complete sex sample. The advantage of our study is that it includes the male and female sexes. Mean arterial pressure and systolic arterial pressure increases with position. However, when the position is corrected after surgery, it falls more than the pre-position value and the patients are hypotensive, and this was found to be statistically significant in our study. Adaptation time does not improve rapidly with the correction of the position. It is low for a while. These values improve in the recovery room. There is not enough data in the literature on this subject.

We do not have complete information about intracranial changes during and after laparoscopic surgery performed in the Trendelenburg position. The information obtained on this subject is in the form of case reports. A case with hemiparesis after urological surgery has been reported (9). After the surgery performed in the Trendelenburg position, it has been found that the brain had cognitive impairment. A change in the mini mental state test has been found in the study (10). However, no change has been detected in other neuroconscious tests. Temporary blindness is observed after laparoscopic surgery (11). Optic nerve damage has been considered as causes of blindness. Neuroconscious values of the patients were not examined in our study. Neurological deterioration was not detected in any of our patients. Neurological defect did not occur. None of our patients had vision problems. Inconsistent results have been found in studies on cerebral oxygen saturation during surgery performed in the Trendelenburg position (5,6,12,13). In the study of Lee JR et al., they have found that the brain oxygen value decreased in the gynecological operation performed in the laparoscopic Trendelenburg position (14). Other studies show that there is no increase or change in cerebral oxygen saturation (12,13). In the study conducted by Park EY et al., it has been found that cerebral oxygen saturation increased with the position during robotic prostatectomy (15). However, there is no study conducted during laparoscopic colorectal surgery. In our study, we detected a significant increase in brain oxygen saturation with the Trendelenburg position. After bringing the position to normal, we saw that this increase continued. The position did not cause deterioration in brain oxygen saturation.

Pneumoperitoneum and Trendelenburg position are performed sequentially during surgery. We think that both Trendelenburg position and pneumoperitoneum affect brain oxygen saturation. However, we think that the Trendelenburg position affects more.

CONCLUSION

The Trendelenburg position and increased intraabdominal pressure during laparoscopic rectal surgery do not impair brain oxygen saturation. On the contrary, it causes an increase in this value.

Ethics Committee Approval: This study was approved by Necmettin Erbakan University Meram Faculty of Medicine Pharmaceutical and Non-Medical Device Ethics Committee (Decision no: 2018/1601, Date: 07.12.2018).

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ORİJİNAL ÇALIŞMA-ÖZET
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Laparoskopik rektum cerrahisinde Trendelenburg pozisyonu ile serebral oksijen satürasyonundaki değişiklikler ve artan intraabdominal basınç

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ÖZET

Giriş ve Amaç: Laparoskopik girişimlerde pozisyon değişiklikleri ve intraabdominal basınç artışı bir takım fizyopatolojik değişikliklere yol açmaktadır. Laparoskopik cerrahiye bağlı oluşan hemodinamik etkiler ile ilgili çalışmaların sonuçları birbirleriyle uyumlu değildir. Kolorektal cerrahi uygulanan hastalarda beyin oksijen satürasyonu ile ilgili literatürde kesin bilgi yoktur. Amacımız laparoskopik rektal cerrahi esnasında pnömoperitoneum ve Trendelenburg pozisyonunda beyin dokusunda oksijen satürasyon değişimi olup olmadığı araştırmaktır.

Gereç ve Yöntem: Çalışma etik kurul onayı alınarak prospektif olarak gerçekleştirildi. Trendelenburg pozisyonunda laparoskopik rektum cerrahisi yapılan 35 hastanın beyin oksijen satürasyonu ölçüldü. Ölçümler genel anestezi altında pnömoperitoneum ve Trendelenburg pozisyonunda yapıldı.

Bulgular: Çalışma laparoskopik rektum cerrahisi uygulanan yedisi kadın, 28'i erkek 35 hasta üzerinden yapıldı. Pozisyondan istatistiksel olarak etkilenen değerler sistolik kan basıncı, ortalama arteriyel kan basıncı ve beyin oksijen satürasyonudur. Trendelenburg pozisyonu beyin oksijen satürasyonunu bozmamakta hatta satürasyonda artmaya neden olmaktadır. Pnömoperitoneum gerçekleştikten sonra sistolik kan basıncı, ortalama arteriyel kan basıncı ve beyin oksijen satürasyonunda değişme tespit edildi. Pnömoperitoneum oluşumu ile beyin oksijen satürasyonu artmaktadır.

Sonuç: Laparoskopik rektal cerrahi esnasında yapılan Trendelenburg pozisyonu ve intraabdominal basınç artışı beyin oksijen satürasyonunu bozmamaktadır.

Anahtar Kelimeler: Laparoskopi, Trendelenburg pozisyonu, beyin oksijen satürasyonu

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