The Effects Of 'Recruitment' Maneuver On Laparoscopic Colon Surgery

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ÖZET

Laparoskopik kolon cerrahisinde recruitment manevrasının etkileri

Amaç: Genel anestezi ve iatrojenik pnömoperiton uygulaması sırasında karın içi basınç artışı, azalmış fonksiyonel rezidüel kapasite ve akciğer kompliansı gibi bazı faktörler atelektazi oluşumuyla sonuçlanır, bu yüzden oksijenizasyon ve arteryel kan gaz parametreleri değişebilir. "Recruitment" manevrası atelektazi oluşumundan korunmak için ve oksijenlenmenin düzelmesi için etkili olabilir. Bu çalışmanın amacı recruitment manevrasının oksijenlenme ve ventilasyon mekanizması üzerindeki etkisini gözlemlemektir.

Gereç ve Yöntem: Bu çalışmada laparoskopik kolon cerrahisi için standart anestezi altında 32 erişkin aday gözlemlenmiştir. İndüksiyon sonrası CO2 akımı ile pnömoperiton oluşturmak için insüflator 2Lt/dk oranına ayarlandı. İşlem süresince karın içi basınç 12 mmHg'de sabit tutuldu. Hastalar rastgele iki gruba ayrıldı. Recruitment grubunda (Recruitment Grubu, n=16) desüflasyondan sonra ventilasyon durduruldu ve 15 saniye 45 cm H2O CPAP uygulandı ve daha sonra 45 saniye ventilasyon takibi ile manevra tekrarlandı. Kontrol grubunda (Kontrol Grubu, n=16) sadece mekanik ventilasyon uygulandı.

Ventilasyon mekaniğini değerlendirmek için dinamik komplians (Cdyn) ölçüldü; sırt üstü pozisyonda entübasyondan sadece 10 dk sonra (indüksiyon 1), pnömoperiton oluşturulduktan 10 dk sonra (insüflasyon- yatay), hastayı 30° Fowler posizyonuna aldıktan sonraki 10 dk (Fowler, 3), 30° Trendelenburg pozisyonda sadece desüflasyon öncesi (Trendelenburg, 4) ve sırt üstü pozisyonda desüflasyondan sonra (desüflasyon- yatay, 5). Eş zamanlı arter kan gazı analizi ölçümleri birinci, ikinci ve beşinci ölçümler uygulandı.

Bulgular: Farklı pozisyonlarda iki grup birbiri ile karşılaştırıldığı zaman Cdyn ölçümü benzerdi. En düşük değer Trendelenburg pozisyonunda ölçüldü. Bu recruitment grubunda 29.2±6.3 ve kontrol grubunda 27.8±8 olarak saptandı. Parsiyel oksijen basınç değeri Recruitment grubunda daha iyi idi. Kontrol grubu için parsiyel oksijen basınç ölçümleri sırasıyla birinci, ikici ve beşinci ölçümlerde 227.3±77.4, 180.5±74.4, 192.5±39.8 mm Hg iken Recruitment grubu için ise sırasıyla 228.9±77.5, 222.6±63.6 and 218.5±48.7 mm Hg'dir.

Sonuç: Laparoskopik kolon cerrahisinde daha iyi oksijenlenme için recruitment manevrasının etkili olduğunu önerebiliriz.

Anahtar kelimeler: Recruitment manevra, laparoskopi, kolon cerrahisi

ABSTRACT

The effects of 'recruitment' maneuver on laparoscopic colon surgery

Objective: During general anesthesia and iatrogenic pneumoperitoneum practice, some factors resulting in formation of atelectasia such as increased intra-abdominal pressure, decreased functional residual capacity and lung compliance can affect the respiratory system therefore due to the oxygenation and arterial blood gas parameters. "Recruitment" maneuver may be effective in prevention of atelectesia and improvement of oxygenation. The aim of this study is observing the effect of recruitment maneuver on ventilation mechanics and oxygenation.

Material and Methods: In this study 32 adult candidates for laparoscopic colon surgery were observed under standard anesthesia. After induction, to create pneumoperitoneum with CO2 flow, the insuflator was set at the rate of 2 L/min. During the procedure the intra-abdominal pressure was kept constant at 12mm-Hg. The subjects randomly were divided into two groups. In recruitment group (Group Recruitment, n=16) we stopped ventilation after desuflation and applied 45 cm H2O CPAP for 15 seconds and then following 45 seconds of ventilation we repeated the maneuver. In control group (Group Control, n=16) only mechanic ventilation but nothing else was applied. For assessment of ventilation mechanics, the dynamic compliance (Cdyn) was measured; just 10 minutes after intubation in supine position (induction, 1), 10 minutes after creating pneumoperitoneum (insuflation-horizontal,2), 10 minutes after putting the patient into Fowler position at 30° (Fowler,3), just before desuflation at 30° Trendelenburg position (Trendelenburg, 4) and after desuflation at supine position (desuflation-horizontal,5). Simultaneous arterial blood gas analysis was performed at first, second and fifth measurements.

Results: Cdyn measurements at different positions were similar when two groups were compared to each other. The lowest value was measured at Trendelenburg position. It was detected as 29.2 ± 6.3 in recruitment group and 27.8 ± 8.2 in control group. Partial oxygen pressure values were better in recruitment group. The partial oxygen pressure measurements were 227.3±77.4, 180.5±74.4, 192.5±39.8 mm-Hg at 1st, 2nd and 5th measurements respectively for control group while they were 228.9±77.5, 222.6±63.6 and 218.5±48.7 mm Hg for recruitment group.

Conclusion: We can suggest that the recruitment maneuver is effective for better oxygenation in laparoscopic colon surgery/interventions.

Key words: Recruitment maneuver, laparoscopy, colon surgery

Bakırköy Tıp Dergisi 2010;6:8-13

INTRODUCTION

Recently, improvement of technology enables us to make most surgical procedures in laparoscopic way. Application of the laparoscopic-videoendoscopic methods for abdominal interventions such as appendectomy, cholecystectomy, inguinal hernia repair, diaphragmatic hernia correction, nephrectomy, splenectomy, adrenalectomy, colectomy and other intestinal resections, vagotomy is gaining acceptance all over the world and is a common practice nowadays (1,2,3).

In laparoscopic surgery insufflation of CO_2 into the abdomen is considered fundamental (4). The iatrogenic pneumoperitoneum created during laparoscopic surgery

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Geliş tarihi / *Date of receipt:* 17 Temmuz 2009 / July 17, 2009

Kabul tarihi / *Date of acceptance:* 28 Ağustos 2009 / August 28, 2009

causes an increase in intra-abdominal pressure. Such factors may cause derangement in gas exchange via affecting respiratory system. Absorption of CO_2 that was insufflated into peritoneum and enlargement of dead space may play role in this derangement (4,5,6).

Different methods like conserving respiratory muscle tonus, reducing resorption atelectesia, generation of positive end expiratory pressure and recruitment maneuver can be used for prevention and correction of atelectesias. Among these methods, recently, the recruitment maneuver is preferred in many operations in an increasing manner (7).

The aim of our study is to discover the effect of recruitment maneuver on ventilation mechanics and blood gas analysis in laparoscopic colon resection surgery via comparing the measurements belonging to recruitment and control groups that were obtained at different positions.

MATERIAL AND METHODS

This study was performed after approval from the ethics committee of Istanbul University Cerrahpasa Medical Faculty and it was conducted in the general surgery operation rooms. The subjects were chosen from candidates for laparoscopic colon resection procedure and ASA II patients were also included. The patients who have respiratory and/or cardiac diseases or those treated with drugs that may derange respiratory function were excluded. The patients having contradictive situations for recruitment, such as hemodynamically unstable state, existence of a cyst or bullae in the lungs or air escape syndromes, were also excluded. From the randomized groups, the one which was treated with recruitment maneuver was called the "Recruitment" group (n=16) and the other one is called the"Control" group (n=16). During the operation the subjects were monitored for heart rate, invasive blood pressure, peripheral oxyhemoglobin saturation (SpO_2) and end tidal carbondioxide ($EtCO_2$) values (Millenia,Orlando,USA). The subjects were premedicated with 0.03 mg/kg intravenous midazolam. After performing Allen test, the nondominant radial artery was catheterized with local anesthesia. Induction was made with 2 mg/kg propofol, 0.1 mg/kg morphine. After administration of 0.15 mg/kg cisatracurium as the neuromuscular blocker, all subjects were intubated and inserted a nasogastric tube. The maintanence of the anesthesia was made with 1-2% sevoflurane, oxygen-air mixture and infusion of remifentanyl at the rate of 0.1- 0.5 μg/kg/min. To maintain the neuromuscular blockage, cisatarcurium was administered intermittently. During the operation, Drager sulla 808V (Lübeck, Germany) was used as mechanic ventilator and the ventilation parameters were set as 0.5 for fiO2, 10 ml/kg for tidal volume, 12/ min for frequency and these values were kept constant during the procedure.

Dynamic compliance (Cdyn) was assessed with Ventrak equipment/device (Ventrak Respiratory Mechanics Monitoring System, Novametrix Medical Systems, Wallingford, Connecticut, USA). Ventilation mechanic measurements were taken 10 minutes after intubation at supine position (induction), 10 minutes after creating pneumoperitoneum (insuflation - horizontal), 10 minutes after putting the patient into Fowler position (Fowler), just before desuflation at 30° Trendelenburg position (Trendelenburg) and after desuflation at supine position (desuflation-horizontal). Simultaneous blood gas analysis was performed at induction, insuflation-horizontal and desuflation-horizontal periods.

In statistical analysis, the number of subjects was determined by power analysis. It was found that the subject number was (had to be) at least 16 for each group and 32 in total (α: 0.05, ß: 0.90). The other statistical tests which used were (matched-paired sample & nonmatched-unpaired sample) student's t test, chi square test, ANOVA (posthoc Tukey-Kramer) test (for/in the repeated measurements). $P< 0.05$ was considered statistically significant. All data is given as ± mean standard deviation or number.

RESULTS

We included 32 patients who were in ASA II group and within the age range of 30-75, and of whom 12 were females, 20 were males. There was no statistically significant difference among the groups in terms of age, weight, length, sex and duration of operation ($p<0.0$, Table 1). In control group, PaO2 values were significantly decreased both in insuflation-horizontal and desuflation-horizontal periods when compared to induction period. Similarly, there was a significant decrease in PaO2 values of insuflation-horizontal period when compared to the values of desuflation-horizontal period ($p<0.05$)

Table 1: The features of the patients and operation (mean ± standard deviation or number)

	Control group	Recruitment group
Number of patients	16	16
Female	7	5
Male	9	11
Age (year)	59±9,8	57±11
Weight (kg)	75,8±12,32	73,9±14,66
Height (cm)	168±6,02	169±7,1
Duration of operation (min)	255±93,04	239,09±138

horizontal periods when compared to those of induction period (p>0.05). The pH values of control group were significantly decreased in desuflation-horizontal period in comparison with insuflation-horizontal period (p<0.05). When the two groups were compared, pH values of insuflation-horizontal period were significantly increased in control group (p<0.05). For rest of the periods, there was no significant difference (p>0.05, Table 2). There were no significant differences in bicarbonate values

Table 2: Perioperative blood gas values (Mean ± Standard deviation)

Periods	Induction	Insuflation-horizontal	Desuflation-horizontal
Control Group PaO_2	227,3±77,4	180,5±74,4*#	192,5±39,8*&#
Recruitment Group PaO_2	228,9±77,5	222,6±63,6	218,5±48,7
Control Group $PaCO_2$	28,5±3,6	37,1±8,9*	45,9±9,8*&#
Recruitment Group PaCO2	33,6±6,8	35,9±5,7	37,8±4,3*
Control Group pH	7,44±0,04	7,41±0,1 *#	7,34±0,05*&
Recruitment Group pH	7,42±0,07	7,37±0,04*	7,34±0,04*
Control Group HCO_3-	22,3±1,3	21,5±1,1	20,9±1,1
Recruitment Group HCO_3-	22,5±1,5	21,6±1,2	21,8±1,2

PaO2 :Partial oxygen pressure; PaCO2: Partial carbondioxide pressure; HCO3- ; Bicarbonate

*(p<0.05) Comparison with induction period, & (p<0.05) Comparison with insufflation-horizontal period, # (p<0.05) Comparison among two groups

In recruitment group PaO_2 values were not significantly changed in neither the insuflation-horizontal nor the desuflation-horizontal period when compared to the induction period (p<0.05). $Pa0_2$ values of the control group in insuflation-horizontal and desuflation-horizontal periods were significantly decreased when compared to the values of the Recruitment group (p<0.05, Table 2). $PaCO_2$ values of control group were significantly increased in insuflation-horizontal and desuflation-horizontal periods compared to induction period (p<0.05). For recruitment group, $PaCO_2$ values of insuflation-horizontal period were not significantly different from induction period (p>0.05), but there was a statistically significant rise in values of desuflation-horizontal period compared to those of induction period (p<0.05).

In comparison of recruitment and control groups, there was no significant difference in $PaCO_2$ values for induction-horizontal period (p>0.05), however $PaCO_2$ values in desuflation-horizontal period were significantly increased in control group when compared to those of Recruitment group (p<0.05, Table 2).

The pH values of both groups were significantly decreased both in insuflation-horizontal and desuflation-

among the periods in both groups, also when the two groups were compared, no significant difference was detected among periods (P>0.005, Table 2).

Cdyn values of control group were significantly decreased in all periods other than induction period (p<0.05). In comparison with insuflation-horizontal period there was no significant difference at/in Fowler position/period (p>0.05); but there was a significant fall in measurements at/in Trendelenburg position/ period (p<0.05), and a significant rise in measurements in desuflation-horizontal period (p<0.05). When compared to Fowler period/position; there was no significant difference in Trendelenburg position/period, but a significant increase in desuflation-horizontal period (p<0.05). Desuflation-horizontal period values were also increased significantly when compared to those of Trendelenburg position/period (p<0.05). Cdyn values of recruitment group were significantly decreased in insuflation-horizontal, Fowler and Trendelenburg periods in comparison with induction period (p<0.05), however there was no significant difference in desuflation-horizontal period (p>0.05). In comparison with insuflation-horizontal period, there was

Table 3: Intraoperative Cdyn values (ml.cmH2O-1) (Mean ± Standard deviation)

Periods	Induction	Insuflation-horizontal	Fowler	Trendelenburg	Desuflation-horizontal
Control Group	52,3±13,3	31,8±10,7*#	30,4±7,6*#	27,8±8,2*#&	44,2± 10,7*#&CD
Recruitment Group	57,5±14,5	33,9±6,3*	36,6±7,9*	29,2±6,3*C	56,4±12,41&CD

Cdyn: Dynamic compliance

*(p<0.05) Comparison with induction period, &(p<0.05) Comparison with insufflation period, #(p<0.05) Comparison among two groups, C(p<0.05) Comparison with Fowler period, D(p<0.05) Comparison with Trendelenburg period

no significant difference in Fowler and Trendelenburg periods (p>0.05), but a significant rise was detected in desuflation-horizontal period (p<0.05). In comparison with Fowler period/position, there was a significant fall in values in Trendelenburg period/position (p<0.05), but a significant rise in desuflation-horizontal period (p<0.05). In comparison with Trendelenburg period/ position, desuflation-horizontal period values showed statistically significant rise (p<0.05). When two groups were compared, cdyn values of induction period were not significantly different (p>0.05), but for the rest of periods there was a significant decrease in control group values when compared to recruitment group values (p<0.05, Table 3).

Neither hemodynamic changes nor unexpected effects or complications were detected in the subjects during or after the operation.

DISCUSSION

There are many ways to increase partial arterial oxygen pressure under general anesthesia just like applying positive end expiratory pressure (PEEP), recruitment maneuver, conserving respiratory muscle tonus or decreasing gas resorption (1,2). The most popular one recruitment is a sort of series of respiratory maneuver that is used to open collapsed alveolus. Laparoscopic colon surgery is also gaining acceptance in the last years and positive results are obtained from these procedures. In this type of procedures ventilation can be effected effected by different causes like pneumoperitoneum, anesthesia, surgery and position.

By applying "recruitment" maneuver in laparoscopic colon surgery we aimed to determine the effects of this maneuver on respiratory system via measuring blood gases and respiratory mechanics.

Rothen et al. (8) studied affectivity of various maneuvers on preventing atelectasia in healthy people during general anesthesia. They increased airway pressure till 10, 20, 30 and 40cmH2O step by step in a group of 10 patients; in another group of 6 patients they applied inflation once till reaching 40cmH2O airway pressure after applying inflation three times till reaching 30cmH_2O airway pressure. They discovered that in 30cmH2O peak inspiratory pressure applications, atelectesia is minimized but not totally disappear, but after applying 40cmH_2O vital capacity maneuver all the atelectasic alveoles are opened and shunts are markedly corrected. In our study "recruitment" maneuver of 45cmH2O pressure is applied twice with a time interval of 45 seconds during the surgery 60 minutes after creating pneumoperitoneum with duration of 15 seconds.

In another study Rothen et al. (9) observed that extending apnea period till 7-8 seconds during the recruitment maneuver makes all the atelectasic areas that is formed after the general anesthesia disappeared and corrects the oxygenation markedly. On the other hand Whalen et al. (10) investigated the effects of alveolar recruitment maneuver and PEEP application during laparoscopic bariatric surgery on arterial oxygenation in their study. In our study a marked increase in partial oxygen pressure that was measured intraoperatively was detected. In our study we used maneuvers similar to those mentioned above. In our study there was a significant decrease in partial arterial oxygen pressure values of the period after desufflation when compared to the period before insufflation in control group, whereas there was no decrease in the partial oxygen pressure values of the recruitment group.

During the pneumoperitoneum period factors such as absorption of CO_2 from peritoneal cavity, decrease in functional residual capacity and lung compliance related to the increase in intraabdominal pressure resulting in elevation of diaphragma can effect respiratory system and cause hypercapnia (11,12). Partial carbon dioxide pressure ($PaCO_2$) values are changed in laparoscopic surgery cases and generally increased proportionally

with the duration of pneumoperitoneum. The study of Demiroluk et al. (13) which include laparoscopic cholecystectomy and laparoscopic inguinal hernia cases proved that there is an increase in $PaCO_2$ values that are taken during the period after pneumoperitoneum. We also determined the increase in $PaCO_2$ values in our study: the increase in $PaCO_2$ values taken after desuflation when compared to the values taken before insuflation was much more significant in control group in comparison with recruitment group.

Hirvonen et al. (14) detected a significant increase in airway pressure after pneumoperitoneum and %30 decrease in the compliance that does not return to the values before pneumoperitoneum. In our study there was a decrease in lung compliance as long as the set of pneumoperitoneum in both groups. The lowest Cdyn values were 20 and 18.4 ml.cmH2O-1 in recruitment and control groups, respectively. In our study, just as in the study of Hirvonen and his colleagues, the decrease in lung compliance was also permanent after terminating pneumoperitoneum for control group but in the recruitment group the values reached the levels before pneumoperitoneum (14). Recruitment maneuver has been helpful in this regard.

The measurable values related to mechanics are also affected from the position of the patient. Similar alterations are also observed in simultaneous blood gas measurements.

Salihoglu et al. (15) performed ventilation mechanics measurement and simultaneous blood gas analysis after pneumoperitoneum in supine, Fowler and Trendelenburg positions in a study which included laparoscopic cholecysistectomy cases. In Trendelenburg position mechanics and blood gas alterations are much more significant, but in Fowler position this deterioration improves. Demiroluk et al. compared laparoscopic surgery applied to morbid obesity patients with traditional open surgery groups in a study that investigate the effects of pneumoperitoneum on ventilation mechanics during bariatric surgery (16). They performed ventilation mechanics measurements and blood gas analysis In both groups and found no marked difference among the groups. A considerable part of gastric bariatric surgery is performed in Fowler position.

In our study the effect of pneumoperitoneum on ventilation mechanics in Fowler position is minimal when compare with supine and Trendelenburg position. Another study supporting this data belongs to another study held by Salihoglu et al (17). They performed their study during laparoscopic gastric band surgery on morbid obesity patients having chronic obstructive lung disease and hypertension. They got the result that reverse Trendelenburg position during laparoscopic gastric band surgery improves oxygenation without any reverse effect on hemodynamics and ventilation mechanics. Similarly in our study peak airway pressure and resistance values increased during supine position after creating pneumoperitoneum, and this increase was exaggerated in Trendelenburg position whereas improved in Fowler position. The decreasing compliance values in Trendelenburg position also improved relatively in Fowler position. When compared to supine position, $PaCO_2$ values are increased in Trendelenburg position while decrease in Fowler position.

In our study no hemodynamic alterations or unexpected effects and complications after or during the surgery were detected in our patients.

According to the data obtained from this study, we can claim that "recruitment" maneuver is an effective and safe method to prevent deteriorations in blood gas values and ventilation mechanics during laparoscopic surgical interventions.

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