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RESEARCH ARTICLE

# Rectal Catheterization for the Diagnosis of Iatrogenic Descending Colon Injuries During $CO_2$ Laparoscopy: An Experimental Study

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## Summary

Only 35.7% of the bowel injuries occurred during $CO_2$ laparoscopy is noticeable intra-operatively. Although air insufflations into the rectum is suggested to identify this injuries, increased risk of contamination of the abdominal cavity by bowel contents makes this procedure abolished. In this experimental study we aimed to evaluate the role of rectal catheterization in the diagnosis of small or unnoticed injuries of the intestines during $CO_2$ laparoscopy. Pneumoperitoneum was created at a pressure level of 12 mmHg in seven white, New Zealand female rabbits. An eight G urinary catheter connected tightly to a urine bag was introduced into the rectum. The descending colon was perforated with the tip of a 21 G needle. Timely $CO_2$ use and the change of urine bag volume were recorded. Methylene blue was used to demonstrate flow into the bag. Significant amounts of gas accumulated in the urinary bag following the perforation of the large bowel and methylene blue flowed into the catheter. Thus, transanal placement of a catheter connected to a urinary bag may help in the diagnosis of small or unnoticed large bowel injuries during laparoscopy.

***Keywords:*** *Rabbit, Laparoscopic injury, Colon, Rectal catheter, Air accumulation, Methylene blue*

# $CO_2$ Laparoskopisi Sırasında İntraoperatif Barsak Yaralanmalarının Tanısı İçin Rektal Kateterizasyon: Deneysel Bir Çalışma

## Özet

$CO_2$ laparoskopisi sırasındaki barsak yaralanmalarının ancak %35.7'si ameliyat sırasında fark edilebilmektedir. Yaralanmaları teşhis edebilmek amacıyla rektuma hava verilmesi düşünülse de, bu uygulama kontamine barsak içeriğinin yayılma şansını arttırabilir. Bu deneysel çalışmada $CO_2$ laparoskopisinde rektal kateterizasyonun küçük ya da fark edilmeyen barsak yaralanmalarındaki rolünü belirlemeyi amaçladık. Yedi tane beyaz, dişi Yeni Zelanda tavşanının karnı 12 mmHg basınca erişene kadar gazla şişirildi. Ucu idrar torbasına sıkıca bağlanmış 8 G idrar sondası tavşan rektumuna yerleştirildi. Bir 21 G iğnenin ucuyla inen kolon delindi. Deney süresince $CO_2$ kullanımı ve idrar torbasında izlenen hacim değişiklikleri kaydedildi. Torbaya akışı göstermek için metilen mavisi kullanıldı. Kolonun delinmesinden sonra anlamlı miktarda gaz idrar torbasında birikti ve metilen mavisi kateter içine aktı. Bu bulguya göre, transanal uygulanan ve idrar torbasına bağlanan bir kateter, laparoskopik cerrahi sırasında oluşabilecek küçük ya da fark edilmeyen barsak yaralanmalarının tanısında yardımcı olabilir.

***Anahtar sözcükler:*** *Tavşan, Laparoskopik yaralanma, Kolon, Rektal kateterizasyon, Hava akümülasyonu, Metilen mavisi*

## INTRODUCTION

Laparoscopic surgery has some potential advantages over laparotomy including less postoperative pain, fewer complications and earlier discharge. However, it has the similar complication risks observed in laparotomy, involving injury to a nearby vital structure, bleeding, and infection [1-4]. The best known risks of laparoscopic procedures are

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related to abdominal cavity access techniques, creation of pneumoperitoneum, use of intra-abdominal energy, and increased anesthesia risks potentialized by the increased intra-abdominal pressure [5-8].

Intra-operative diagnosis of a complication increases the chance of avoiding further hazardous injury to the effected tissue. Although gross vascular injuries are diagnosed instantaneously, minor bowel injuries may be unnoticed and result in the contamination of the abdominal viscera. Intra-operative diagnosis of a bowel injury, either provide the excellent chance for an immediate repair or prevent the late complications involving ileus, abscess formation or sepsis. In a study aiming to specify the circumstances under which the gastrointestinal injuries occur, the researchers [9,10] reported that only 35.7% of the injuries could be noticed intra-operatively. An additional 48.3% of the injuries could be diagnosed in the first post-operative week. Moreover, the remaining 16% of the injuries could be diagnosed after the first postoperative week [9]. The time of the diagnosis was most likely to elongate if the injury was in the bowel and resulted from the use of electro surgery [9,10].

Although some authors [7] suggest the routine insufflations of air into the rectum to identify small injuries in cases of extensive adhesions, the procedure may increase the chance of the dissemination of the contaminated bowel contents into the abdominal cavity.

Previous studies demonstrated the role of prompt intra-postoperative diagnosis of the bowel perforations which may significantly decrease the rates of morbidity and mortality. In this experimental study we aimed to evaluate the role of intra-operative rectal catheterization in the diagnosis of small or unnoticed injuries of the intestines during $CO_2$ laparoscopy. Our study may aid in the early diagnosis of intestinal injuries occurred during $CO_2$ laparoscopy and change the standard diagnostic strategy depended on expectant management. In addition, evidence based diagnostic approach may also prevent many unnecessary major surgical procedures.

## MATERIAL and METHODS

The study was carried out in the Surgery Department of Kafkas University Faculty of Veterinary Medicine between 15$^{th}$ and 21$^{st}$ of August 2011. Before starting the experiments the study was approved by the Animal Ethics Committee of Kafkas University (KAU-HADYEK/2011-26). The participating animals were provided by University of Kafkas Faculty of Veterinary Medicine.

We used seven white New Zealand female rabbits in the experiment. All the rabbits were 2 years old and weighted between 3130 and 3460 g. Before anticipating the experimental procedure all the rabbits were fed as usual until the last six hour of the preoperative period. Oral alimentation and hydration were prohibited six hour before the induction of anesthesia. The rabbits received no special medication for bowel preparation. In order to achieve prophylaxis against intra-operative infection, a single dose of 80 mg/ kg cefazoline sodium was administered intramuscularly one hour before the start of the surgical procedure. All operations were performed between 5 and 7 p.m. on separate days by the same surgical team.

In all 7 rabbits intramuscular 10 mg/kg xylazin HCl (Rompun® 2% 50 ml Bayer) and 30 mg/kg ketamin HCl (Ketasol 10% inj, 10 ml vial Richter Pharma) were used for the induction of the anesthesia. Sevoflurane 2-2.5% mixed with dry air was used for the maintenance of the anesthesia.

Anterior abdominal wall was routinely prepared by shaving and the surgical area was prepared with 10% polyvinylpyrrolidone iodine. Through the 2-3 mm sub-umbilical incision the Veress needle was introduced into the abdominal cavity, and following the insufflations of $CO_2$ pneumoperitoneum was maintained at an intra-abdominal pressure level of 12 mmHg. The skin incision was enlarged to 6 mm and a 5 mm trocar was introduced into the abdominal cavity. Through the 5 mm trocar the telescope was introduced and the abdominal cavity was visualized. A second paramedian 2 mm port was inserted to manipulate the intra abdominal tissues. At an intra-abdominal pressure level of 12 mmHg the prevention of gas leakage was checked by the observation of the automatic cease of the gas inflow.

The initial phase of the experiment was mainly observational. An eight G urinary catheter connected tightly to an empty urine bag was introduced 10 cm into the rectum and the balloon of the catheter was inflated with 5 ml of saline *(Fig. 1)*. Other than moving the catheter slightly (1-2 cm up and down) along its longitudinal axe and spinning it around its transverse axe, the operative setting was not changed for 5 min and the changes of gas flow, intra-abdominal pressure and the volume of the urine bag were recorded.

In the second phase of the experiment, the line of the rectal catheter was clamped first. Under telescopic view a 21 G needle was inserted into the abdominal cavity. The tip of the needle was oriented to the anti-mesenteric wall of the descending colon and the colon was perforated approximately 10 cm above the point of insertion of the rectum into the pelvic base *(Fig. 2)*. The needle was taken outside the abdominal cavity. Prevention of gas leakage was checked as defined previously. At the point where the gas flow ceased along with an intra-abdominal pressure of 12 mmHg, the rectal catheter was unclamped. Other than moving the catheter slightly (1-2 cm up and down) along its longitudinal axe and spinning it around its transverse

**Fig 1.** Experimentation in a rabbit during $CO_2$ laparoscopy. Perforation of the descending colon with the tip of a 21 G needle caused the distension of the urinary bag connected to the catheter inserted into the rectum of the rabbit

**Şekil 1.** $CO_2$ laparoskopisi sırasında bir tavşandaki deney. 21 G iğnenin ucu ile inen kolonun delinmesiyle rektuma yerleştirilen kateter yoluyla kateter ucuna bağlı idrar torbasının şişmesi

**Fig 2.** Perforation of the descending colon under telescopic view by using the tip of a 21 G needle

**Şekil 2.** Teleskopik görüntü altında 21 G iğnenin ucu kullanılarak inen kolonun delinmesi

axe, the operative setting was not changed for 5 min and the changes of gas flow, intra-abdominal pressure and the volume of the urine bag were recorded for the next 5 min.

In the third phase of the experiment 50 ml of methylene blue was injected into the abdominal cavity and the rectal catheter was observed for 5 min.

At the end of the experiment the abdominal cavity was deflated and the incision of the abdominal entry site was closed with number 2-0 delayed absorbable sutures.

The first two operated rabbits died the next day after the operation with the clinical symptoms of generalized peritonitis and sepsis, thus in order to prevent unnecessary suffering of the animals, the remaining five rabbits were sacrificed at the end of the experiment by the administration of 100 mg intramuscular xylocaine and 200 mg/kg intra-cardiac ketamine.

Statistical analyses were performed using SPSS version 16.0 software (SPSS Inc, Chicago, IL). The amounts of $CO_2$ use at each phase and the weights of the rabbits were evaulated by using the Kolmogorov-Smirnov Z test. The amounts of the used $CO_2$ and the estimated changes of the volume of the urinary bags during each three phases of the study were compared by using Friedman's and Wilcoxon's tests. Correlations between the study parameters were analysed by using Spearman's test. A P value of $<0.05$ was considered significant.

## RESULTS

In five of the cases, although the gas accumulation in the urinary bags was observed initially, the gas flow ceased due to the obstructions of the catheters. Slight movements of the catheter around itself and upward or downward reconstructed the gas flow into the urinary bag in four of the cases; however in one case we had to take the catheter, clean the obstructed tip and reinsert into the rectum in order to reconstruct the gas flow into the urinary bag.

The weights of the rabbits and the initial amount of $CO_2$ used for the creation of pneumoperitoneum did not differ among the participating rabbits ($P>0.05$). We did not observe any $CO_2$ flow at the first phase of the experiment, thus there was not any $CO_2$ use or $CO_2$ accumulation in the urinary bags. However, we observed $CO_2$ flow and $CO_2$ accumulation in the urine bags *(Fig. 1)* in all the participating animals in the second and third phase of the study *(Table 1)*. In addition methylene blue flow into the line of the urinary bag was observed in all seven cases.

Statistical analysis by using Friedman's and Wilcoxon's tests showed that the amounts of used $CO_2$ and accumulated $CO_2$ in the urinary bags were significantly different ($P<0.05$). The used $CO_2$ was significantly highest in the second phase and lowest in the first phase ($P<0.05$). Similarly, the accumulation of gas in the urinary bags was significantly highest in the second phase and lowest in the first phase ($P<0.05$). Both the amount of $CO_2$ use and urinary bag accumulations were significantly different in each phase of the study *(Table 2)*.

***Table 1.*** *Comparison of some selected parameters of seven rabbits. The values are presented as mean ± standard deviation or percent (%)*
***Tablo 1.*** *Yedi tavşana ait bazı seçilmiş verilerin karşılaştırılması. Değerler, ortalama ± standart sapma ya da yüzde (%) şeklinde sunulmuştur*

| Characteristics | Mean ± Standard Deviation | P Value* |
|---|---|---|
| Weight of the rabbits | 3.27±1.11 | 0.540 |
| Initial amounts of $CO_2$ used to maintain the abdominal pressure of 12 mmHg (ml) | 857.14±1.81 | 0.564 |
| $CO_2$ use in the 1st phase ǂ of the experiment (ml) | 0 | N/A |
| $CO_2$ use in the 2nd phase ǂǂ of the study (ml) | 1271.43±149.60 | 0.423 |
| $CO_2$ use in the 3rd phase ǂǂǂ of the study (ml) | 814.28±121.50 | 0.675 |
| Increase of estimated urinary bag volume in the 1st phase (ml) | 0 | N/A |
| Increase of estimated urinary bag volume in the 2nd phase (ml) | 785.71±94.49 | 0.726 |
| Increase of estimated urinary bag volume in the 3rd phase (ml) | 471.43±111.27 | 0.457 |
| Methylene blue in the urinary catheter or bag (%) | 100 | N/A |

** Kolmogorov-Smirnov Z test,* ***ǂ 1st phase:*** *5 min interval following the placement of rectal catheter,* ***ǂǂ 2nd phase:*** *5 min interval following the perforation of the large bowel with the tip of a 21 G needle,* ***ǂǂǂ 3rd phase:*** *5 min interval following the intra abdominal administration of methylene blue*

***Table 2.*** *Comparison of the parameters at different phases of the study. The values are presented as mean ± Standard deviation*
***Tablo 2.*** *Çalışma parametrelerinin farklı fazlarda karşılaştırılması. Değerler ortalama± standart sapma olarak sunulmuştur*

| Parameter | 1st Phaseǂ | 2nd Phaseǂǂ | 3rd Phaseǂǂǂ | P Value |
|---|---|---|---|---|
| $CO_2$ use (ml) | 0 | 1271.43±149.60 | 814.28±121.50 | 0.001* |
| Estimated urinary bag volume increase (ml) | 0 | 785.71±94.49 | 471.43±111.27 | 0.001* |
| | **1st Phase** | **2nd Phase** | | |
| $CO_2$ use (ml) | 0 | 1271.43±149.60 | | 0.018** |
| Estimated urinary bag volume increase (ml) | 0 | 785.71±94.49 | | 0.017** |
| | **1st Phase** | **3rd Phase** | | |
| $CO_2$ use (ml) | 0 | 814.28±121.50 | | 0.017** |
| Estimated urinary bag volume increase (ml) | 0 | 471.43±111.27 | | 0.017** |
| | **2nd Phase** | **3rd Phase** | | |
| $CO_2$ use (ml) | 1271.43±149.60 | 814.28±121.50 | | 0.017** |
| Estimated urinary bag volume increase (ml) | 785.71±94.49 | 471.43±111.27 | | 0.017** |

** Friedman test, **Wilcoxon signed ranks test,* ***ǂ 1st phase:*** *5 min interval following the placement of rectal catheter,* ***ǂǂ 2nd phase:*** *5 min interval following the perforation of the large bowel with the tip of a 21 G needle,* ***ǂǂǂ 3rd phase:*** *5 min interval following the intra abdominal administration of methylene blue*

Correlation analysis showed that the weight of the rabbits, initial $CO_2$ use for creating pneumoperitoneum, and the $CO_2$ use in the second and third phase of the experiment correlated with each other ($P<0.05$), however the amount of $CO_2$ accumulated in the second and third phase of the experiment (although correlated with each other) did not correlated with the abovementioned parameters ($P>0.05$).

# DISCUSSION

### *Principal Findings*

In this experimental study we demonstrated that a complete penetrating injury of the large bowel (even as small as the tip of a needle) during laparoscopic surgery causes the diffusion of $CO_2$ into the large bowel. Trans rectal insertion of a urinary catheter tightly connected to a urinary bag may help diagnosing the bowel injury after observing the inflation of the urinary bag. The accumulation of the intra-abdominally administered methylene blue in the urinary bag makes the diagnosis certain.

### *Strengths*

To our knowledge this is the first study offering the insertion of a urinary catheter into the rectum in order to diagnose the small or unnoticed bowel injury during $CO_2$ laparoscopic surgery. Although some authors suggested transanal insufflations or methylene blue administrations [7,9], both procedures may enhance the dissemination of the contaminated contents of the bowel, particularly the large one. In contrast our technique requires the flow of gas from intra-abdominal cavity into the intestines and the catheter placed in the rectum, thus reasonably may decrease the rates of contamination. Although first two rabbits participated in our study died with the findings of peritonitis and sepsis, there was no bowel preparation at the beginning of the study and the contamination at the time of the bowel perforation may be the reason. In order to compare the effect of our technique on bacterial

contamination with the previous ones we need further studies.

Another favorable characteristic of our technique is its simplicity and easily accessible nature in every operative theatre setting.

***Limitations***

Rectally placed catheter may identify the bowel injury which affects all layers of the intestinal wall. However abrasions, lacerations and cautery burns that may cause delayed perforations or obstructions are missed. In addition, it is almost impossible to find the exact place of the injury in where the injury site is very small. Intra abdominal administration of methylene blue also seems unhelpful for this purpose.

Although we presented the amounts of $CO_2$ used and accumulated in the urinary bag in every phase of the study, the reader should notice that the values were mostly estimated. The used $CO_2$ values were red from the insufflator device which only showed one decimal and the accumulated $CO_2$ in the urinary bags were estimated by the appearance and the covered scale of the bags.

The perforation was simulated on the descending colon, thus we can not state the findings for the perforations located on the proximal parts of the intestines.

***Comparison with the Previous Studies***

Creation of pneumoperitoneum during laparoscopy is critical because more than half of the complications occur at this stage [9,10] and one-third (34.5%) of the complications are related with the gastrointestinal system. In addition 48.4% of the gastrointestinal complications involve the large bowel [8]. However, only one-third (35.7%) of the complications are noticed intra-operatively. Moreover, the mortality rate of unrecognized bowel injuries was found 21% [12].

Upper bowel injuries may be free or contained within the surrounding structures, however, lower bowel injuries are nearly always free and the intestinal contents spill into the abdominal cavity. In addition the foul smell of the intestinal contents and bleeding at the site of injury may help in intra operative diagnosis. However, elevated intra abdominal pressure in $CO_2$ laparoscopy may cause the leakage of the gas into the perforated bowel and obscure the signs of perforation, particularly in small injuries. Reasonably the chance of spill of the bowel contents and sensing of the foul smell is less during laparoscopy. Thus, for the small and unnoticed perforations the diagnosis depends on the suspicion. Obesity, endometriosis, malignancy, dense adhesions and extensive adhesiolysis are the predisposing factors associated with bowel injury [11,13-18]. However, high suspicion and laparoscopic exploration do not guarantee the diagnosis of a small perforation.

In order not to miss an intra operative iatrogenic bowel perforation, some authors suggest the routine insufflations of air into the rectum [7] and/or transanal injection of 200 ml methylene blue [9] using a Foley catheter to identify small injuries in cases of extensive adhesions. However, these procedures carry the risk of the dissemination of the contaminated bowel contents into the abdominal cavity. In addition, in order to provide the flow of transanal gas or methylene blue into the abdominal cavity the pressure inside the bowel must exceed the intra abdominal pressure which in turn may enlarge the injury dimensions and obscure the surgical view after the dilatations of the intestines. In our technique the flow of the gas or methylene blue is from inside towards outside and it does not increase the risk of contamination or the rate of bowel dilatation. However our technique may be insufficient in diagnosing the exact location of the injury.

In our study intra abdominal methylene blue was used for demonstrative purposes. It was not a part of the technique. Thus in the diagnostic workup of an intra -operative bowel injury, we think that insertion of a catheter into the rectum and observation of the distension of the connected urinary bag should be the first step. If the operators are convinced on the diagnosis of perforation and the exact location of the perforation is not demonstrable, then transanal injection of methylene blue may be considered.

In a study [19] performed to evaluate the feasibility of methylene blue as a marker to detect the gastric perforations, the researchers demonstrated the extra-vasations of methylene blue during laparoscopic surgery with the perforations of 1.2 mm and greater with or without air insufflations. Air extravasation was seen with perforations of 2.0 mm and greater in the same study. In our study we did not measure the specific diameter of the each individual injury; however we created the injury by using a 21 G needle with an outer diameter of 0.8 mm. Although we did not perform a colonoscopic examination to determine the extravasations of methylene blue or air into the intestinal lumen, we demonstrated both the air and methylene blue in the urinary bag connected to the rectal catheter. The amounts of the used $CO_2$ and accumulated air in the urinary bag were significantly less after using methylene blue in comparison before using methylene blue ($P<0.05$). Probably, the slower extravasation of the methylene blue with a higher viscosity compared to $CO_2$ was the explanation for the phenomena.

***Meaning of the Study and Clinical Implications***

Our experiment demonstrated that bowel injury during $CO_2$ laparoscopy may be diagnosed by inserting a catheter tightly connected to a urinary bag. However, it should be remembered that the injury should involve the whole intestinal wall connecting the intestinal lumen and the intra abdominal cavity. According to our study settings

the technique is helpful with an injury diameter of 0.8 mm or greater.

Although the diagnostic technique worked in our experimental study, we do not have evidence about its use in human beings. Further clinical studies performed on human beings may provide the evidence about the efficiency of the technique in routine daily practice. In our study we used an eight G urinary catheter and did not have preoperative bowel preparation. In human beings the bowels are usually prepared preoperatively and it is possible to use larger rectal catheters with larger lumens. Thus, it is reasonable to think that the technique will be more efficient in humans.

According to our study the distension of the urinary bag defines the perforation of the large bowel. However, we do not know whether the technique is applicable for upper intestinal injuries or not. Another important issue is encountered in cases where the urinary bag does not distend. Does it exclude perforation? Does it exclude perforation only at large bowel. We believe that large bowel perforations at the time of the applications may be diagnosed. However, incomplete injuries or necrotic burn injuries which lead to delayed perforations may be incorrectly diagnosed as if there is not an injury. Thus in clinical practice and studies patients with negative tests should be followed for an adequate period of time.

Transanal placement of a catheter connected to a closed system may help in the diagnosis of small or unnoticed large bowel injuries during laparoscopy.

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