J Surg Med. 2019;3(12):837-840.
DOI: 10.28982/josam.585425

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN: 2602-2079

Pneumoperitoneum in laparoscopic surgery: Comparison of the effect on gastric and intestinal motility in pediatric and adult rats

Laparoskopik cerrahide pneumoperiton: Pediatrik ve erişkin ratlarda gastrik ve intestinal motilite üzerine etkisinin karşılaştırılması

Umut Alıcı [1], Ahmet Unlu [2], Yasemin Aydın [3], Baran Tokar [1]

[1] Department of Pediatric Surgery, Eskişehir Osmangazi University Medical School, Eskişehir, Turkey
[2] Atatürk Training and Research Hospital, Antalya, Turkey
[3] Department of Physiology, Eskişehir Osmangazi University Medical School, Eskişehir, Turkey

ORCID ID of the author(s)

UA: 0000-0002-3250-724X
AU: 0000-0002-6976-0652
YA: 0000-0003-4992-1153
BT: 0000-0002-7096-0053

Abstract

Aim: There are limited data on how pneumoperitoneum used during laparoscopy affects gastric and intestinal motility in children compared to adults. The aim of this experimental study is to measure and compare the effects of pneumoperitoneum on the gastric and small intestinal motility among children and adult rats.

Methods: The study was conducted with 4 groups: Groups 1 and 2 (n=8 and 7, respectively) comprised pediatric rats while Groups 3 and 4 (n=10 and 10, respectively) included adult rats. Pneumoperitoneum was achieved in Groups 1 and 3. Laparotomy was performed in Groups 2 and 4. The duration of procedure was 90 minutes in all groups. CO_2 (Thermoflator, Karl-Storz, Germany) insufflation pressure was maintained at 5 mHg-0.5 ml/min. Postoperative gastric and intestinal motility studies were performed in all groups. Contractile responses to Acetylcholine and potassium chloride (at a dose range of 10^{-8} to 10^{-3} mM) were recorded (Isometric Transducer, Biopac, USA). Data Collection Analysis System (MP100 Biopac, USA) was used to analyze the data.

Results: The lowest contraction response was obtained in group 1 for both the stomach and intestine. The responses of pediatric groups to potassium chloride and acetylcholine were lower than those of adult groups, but there was no significant difference among the 4 groups ($P>0.05$).

Conclusion: This study may suggest that in the similar setting for pediatric and adult age groups, pneumoperitoneum does not significantly adversely affect gastric and small intestinal motility in children. Future studies should aim to investigate the effects of pneumoperitoneum on gastric and intestinal motility at different ages, weights, types of anesthesia, intra-abdominal pressures and operative duration.

Keywords: Laparoscopy, Pneumoperitoneum, Gastric motility, Intestinal motility, Child

Öz

Amaç: Literatürde, pnömoperitonun erişkinlere kıyasla çocuklarda mide ve bağırsak hareketliliğini nasıl etkilediği konusunda sınırlı veri bulunmaktadır. Bu deneysel çalışmanın amacı, çocuklarda ve yetişkin sıçanlarda pnömoperitonun gastrik ve ince bağırsak hareketliliği üzerindeki etkilerini ölçmek ve karşılaştırmaktır.

Yöntemler: Çalışma 4 grupta yapıldı. Grup 1'de (n=8) ve 2'sinde (n=7) pediatrik yaşta, grup 3'te (n=10) ve 4'ünde (n=10) yetişkin yaşta sıçanlar vardı. Grup 1 ve 3'te pnömoperiton uygulandı. Grup 2 ve 4'te laparotomi yapıldı. İşlem süresi tüm gruplarda 90 dakika idi. CO_2 insüflasyonu (Thermoflator, Karl-Storz, Almanya) 5 mHg-0,5 ml/dk basınçta uygulandı. Postoperatif mide ve bağırsak motilite çalışmaları tüm gruplarda yapıldı. Asetilkolin ve KCl'ye (10^{-8} ila 10^{-3} mM'lik bir doz aralığında) kontraktil cevaplar kaydedildi (İzometrik Dönüştürücü, Biopac, ABD). Verilerin analizinde Veri Toplama Analiz Sistemi (MP100 Biopac, ABD) kullanılmıştır.

Bulgular: En düşük kasılma cevabı, hem mide hem de bağırsak için grup 1'de elde edildi. Pediatrik grupların potasyum klorid ve asetilkoline verdiği yanıtlar yetişkin gruplardan daha düşüktü, ancak 4 grup arasında anlamlı fark yoktu ($P>0,05$).

Sonuç: Bu çalışma, pediatrik ve erişkin yaş grupları için benzer bir ortamda, pnömoperitonun çocuklarda mide ve ince bağırsak hareketliliği üzerinde önemli bir olumsuz etki yapmadığını ortaya koyabilir. Gelecekteki çalışmalar, farklı yaşlarda, ağırlıklarda, anestezi tiplerinde, karın içi basınç ve sürelerinde pnömoperitonun mide ve bağırsak hareketliliği üzerindeki etkilerini araştırmayı amaçlamalıdır.

Anahtar kelimeler: Laparoskopi, Pneumoperiton, Gastrik motilite, İntestinal motilite, Çocuk

Corresponding author / Sorumlu yazar:
Umut Alıcı
Address / Adres: Çocuk Cerrahisi Anabilim Dalı, Eskişehir Osmangazi Üniversitesi, Tıp Fakültesi Eskişehir, Türkiye
e-Mail: drualici@gmail.com

Ethics Committee Approval: The approval of the Ethics Committee of Eskişehir Osmangazi University Faculty of Medicine and the Experimental Animal Research Sub-Commission (Resolution 53 dated 15 March 2007) was obtained.
Etik Kurul Onayı: Eskişehir Osmangazi Üniversitesi Tıp Fakültesi Etik Deney Komitesi ve Deneysel Hayvan Araştırmaları Alt Komisyonu'nun onayı (15 Mart 2007 tarihli ve 53 sayılı Karar) alındı.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 12/16/2019
Yayın Tarihi: 16.12.2019

How to cite / Atıf için: Alıcı U, Unlu A, Aydın Y, Tokar B. Pneumoperitoneum in laparoscopic surgery: Comparison of the effect on gastric and intestinal motility in pediatric and adult rats. J Surg Med. 2019;3(12):837-840.

Introduction

Laparoscopic abdominal surgery is expected to shorten postoperative recovery time, hospitalization, and duration of return to daily activities. Early postoperative oral intake is one of the major concerns that determine the quality of postoperative follow-up in laparoscopic surgery. Starting early enteral feeding depends on gastrointestinal system (GIS) motility [1].

Pneumoperitoneum via CO_2 insufflation increases intraabdominal pressure (IAP), which may induce motility problems in GIS to possibly result in postoperative ileus and spontaneous ileum perforation [2].

High IAP also increases pressure on the abdominal vena cava, which may cause a decrease in venous blood flow and consequently, the GIS. Clinical and experimental studies show that increased IAP may cause high venous resistance, hypoxic mucosal and neuronal injury and contractility and motility disorders in the gastrointestinal system [2-4]. The intestinal neuronal network, located between the longitudinal and circular muscle layers, releases neurotransmitters responsible for induction of GIS contractility and motility, and it may be damaged by high IAP and significant intraabdominal distension.

Although there are studies investigating the effects of pneumoperitoneum on GIS motility in adults, there is no study on this specific subject in children. In this experimental study, the contractility response of children and adult rats were compared by measuring the effects of pneumoperitoneum on gastric and small intestinal motility.

Materials and methods

The study was conducted at Eskisehir Osmangazi University (ESOGU) Medical and Surgical Research Center (TICAM) with approval of ESOGU Medical School Ethics Committee Sub-Commission on Experimental Animal Research. Forty Sprague-Dowley rats were used. Surgery could not be completed in two rats in group 1 and 3 rats in group 2, which were excluded. Motility study was completed in 35 rats. The ages and weights of rats in Groups 1 (n=8) and 2 (n=7), the pediatric rat groups, ranged between 20-25 days and 49-75 grams, respectively. Groups 3 (n=10) and 4 (n=10) included adult rats aged between 2-3 months that weighed between 300-400 grams. Pneumoperitoneum was achieved in Groups 1 and 3, while laparotomy was performed in Groups 2 and 4.

Surgical procedure and motility study

All rats received 80 mg/kg intramuscular ketamine hydrochloride (Ketalar, Pfizer, USA) and 4 mg/kg midazolam (Dormicum, Roche, Germany). Duration of the procedure was 90 minutes in all groups. Pneumoperitoneum with CO_2 insufflation was achieved by the insufflator (Thermoflator, Karl Storz, Germany) with a flow rate of 0.5 ml/min at 5 mmHg pressure in Groups 1 and 3 with 60 minutes insufflation, 30 minutes desufflation periods. To obtain pneumoperitoneum, insufflator was connected to a 14 G intravascular catheter placed intraperitoneally. At that pressure and flow rate, a marked abdominal distension was preserved throughout the procedure. The insufflation was terminated, and laparotomy was performed to obtain gastric and ileal specimens. A four-cm-long ileal segment that was located 10 cm proximal to cecum and gastric fundus were resected and immersed into the freshly prepared Tyrod solution for the motility study. The experimental animals were sacrificed under anesthesia after removal of tissue samples.

Afterwards, the removed stomach and ileum pieces were placed in the isolated organ bath, fixed at 37 degrees Celsius and receiving a gas mixture of 95% oxygen and 5% CO_2. The same size of bowel and stomach was used in each study. In the isolated organ bath, passive stretching tension of 1 G was applied to each bowel and stomach piece. At the end of this period, 10^{-8} mM of acetylcholine and 10^{-3} mM of potassium chloride were given cumulatively at regular intervals. Contraction responses were recorded by the data acquisition system (MP100 Biopac, USA).

In groups 2 and 4, laparotomy was performed with a 0.5 cm median incision. At the end of 90 minutes, gastric and ileal specimens were resected, and motility studies were performed as described for the groups 1 and 3.

Statistical analysis

Using SPSS 15.0 and SigmaStat 3.1 package programs, two-factor repetitive measurement variance analysis (Two Way Repeated Measures ANOVA), Tukey HSD and Holm-Sidak tests were performed in multiple comparisons.

Results

The lowest contraction response was obtained in group 1 for both the gastric fundus and intestine. The contraction responses of pediatric groups (Group 1 and 2) to potassium chloride and acetylcholine were lower than those of adult groups (Group 3 and 4) in all doses for both the gastric fundus and ileum (Table 1-8) (Figures 1, 2). Statistical comparison of contraction responses of all groups showed that there was no significant difference among the 4 groups (P>0.05).

Table 1: Comparison of ileum contraction responses to potassium chloride

Dose	Group 1 (n=8) Mean (SD) mN	Group 2 (n=7) Mean (SD) mN	Group 3 (n=10) Mean (SD) mN	Group 4 (n=10) Mean (SD) mN
2 mM	0.15 (0.2)	0.14 (0.14)	0.25 (0.5)	0.32 (0.36)
4 mM	0.16 (0.17)	0.25 (0.28)	0.44 (0.34)	0.74 (0.51)
8 mM	0.31 (0.31)	0.51 (0.44)	1.04 (0.59)	1.75 (0.73)
16 mM	0.6 (0.67)	1.19 (1.13)	2.5 (1.91)	3.06 (1.2)
32 mM	0.5 (0.62)	1.24 (1.38)	2.74 (2.05)	2.63 (1.0)

mN: Milinewtons, SD: Standard deviation

Table 2: Comparison of the responses of ileum to potassium chloride in organ baths between groups

Groups	Mean (SD)	P-value	Critical level
1-2	0.29 (0.84)	0.41	0.01
1-3	0.38 (1.13)	0.27	0.01
1-4	0.06 (0.18)	0.86	0.05
2-3	0.09 (0.28)	0.78	0.02
2-4	0.23 (0.67)	0.51	0.02
3-4	0.32 (0.95)	0.35	0.01

SD: Standard deviation

Table 3: Comparison of gastric fundus contraction responses to potassium chloride

Dose	Group 1 (n=8) Mean (SD) mN	Group 2 (n=7) Mean (SD) mN	Group 3 (n=10) Mean (SD) mN	Group 4 (n=10) Mean (SD) mN
2 mM	0.12 (0.18)	0.1 (0.09)	0.19 (0.23)	0.47 (0.7)
4 mM	0.21 (0.25)	0.2 (0.15)	0.34 (0.39)	0.68 (0.79)
8 mM	0.32 (0.31)	0.39 (0.21)	0.56 (0.49)	1.75 (0.99)
16 mM	0.6 (0.51)	1.19 (1.13)	2.5 (1.91)	0.81 (1.2)
32 mM	0.35 (0.62)	0.63 (0.24)	1.02 (0.66)	1.43 (0.7)
64 mM	0.74 (0.33)	0.96 (0.41)	2.5 (1.1)	3.14 (0.78)

mN: Milinewtons, SD: Standard deviation

Table 4: Comparison of the responses of gastric fundus to potassium chloride in organ bath between groups

Groups	Mean (SD)	P-value	Critical level
1-2	0.01 (0.04)	0.97	0.05
1-3	0.3 (0.86)	0.40	0.02
1-4	0.68 (1.95)	0.06	0.01
2-3	0.28 (0.82)	0.42	0.02
2-4	0.67 (1.92)	0.07	0.01
3-4	0.38 (1.1)	0.29	0.01

SD: Standard deviation

Table 5: Comparison of ileum contraction responses to acetylcholine

Dose	Group 1 (n=8) Mean (SD) mN	Group 2 (n=7) Mean (SD) mN	Group 3 (n=10) Mean (SD) mN	Group 4 (n=10) Mean (SD) mN
-9 mM	0.63 (0.59)	0.74 (0.19)	0.97 (0.85)	1.17 (1.02)
-8 mM	0.61 (0.5)	0.81 (0.38)	1.5 (1.22)	1.9 (0.79)
-7 mM	0.72 (0.53)	0.86 (0.32)	2.19 (1.22)	2.89 (0.74)
5x-7 mM	0.9 (0.68)	1.31 (0.81)	3.14 (1.14)	3.73 (1.91)
-6 mM	0.8 (0.72)	1.25 (0.86)	2.92 (1.44)	1.43 (4.24)
5x-6 mM	1.05 (0.95)	1.64 (1.34)	3.55 (1.77)	5.21 (2.62)
-5 mM	0.76 (0.68)	1.35 (1.29)	3.02 (2.13)	3.92 (1.79)
5x-5 mM	0.72 (0.64)	1.36 (1.45)	3.38 (4.44)	4.31 (1.45)

mN: Milinewtons, SD: Standard deviation

Table 6: Comparison of the responses of ileum to acetylcholine in organ bath between groups

Groups	Mean (SD)	*P*-value	Critical level
1-2	0.48 (1.46)	0.16	0.01
1-3	0.79 (2.42)	0.03	0.01
1-4	0.87 (2.64)	0.02	0.01
2-3	0.32 (0.96)	0.35	0.02
2-4	0.39 (1.18)	0.25	0.02
3-4	0.07 (0.22)	0.83	0.05

SD: Standard deviation

Table 7: Comparison of gastric fundus contraction responses to acetylcholine

Dose	Group 1 (n=8) Mean (SD) mN	Group 2 (n=7) Mean (SD) mN	Group 3 (n=10) Mean (SD) mN	Group 4 (n=10) Mean (SD) mN
-9 mM	0.13 (0.15)	0.45 (0.56)	0.74 (0.55)	0.74 (0.41)
-8 mM	0.19 (0.18)	0.49 (0.57)	0.95 (0.61)	0.97 (0.57)
-7 mM	0.22 (0.14)	0.63 (0.68)	1.14 (0.82)	1.13 (0.74)
5x-7 mM	0.27 (0.16)	0.76 (0.79)	1.49 (1.15)	1.55 (1.05)
-6 mM	0.31 (0.17)	0.83 (0.85)	1.64 (1.28)	1.68 (1.13)
5x-6 mM	0.37 (0.17)	0.99 (0.94)	2.25 (1.46)	2.27 (1.31)
-5 mM	0.41 (0.18)	1.05 (1.0)	2.47 (1.63)	2.56 (1.33)
5x-5 mM	0.48 (0.2)	1.2 (1.06)	3.27 (1.84)	3.4 (1.45)
-4 mM	0.53 (0.19)	1.26 (1.08)	3.40 (1.9)	3.58 (1.5)
5x-4 mM	0.69 (0.25)	1.43 (1.13)	4.04 (1.12)	4.21 (1.61)
-3 mM	0.75 (0.21)	1.49 (1.13)	4.25 (2.17)	4.50 (1.6)

mN: Milinewtons, SD: Standard deviation

Table 8: Comparison of the responses of gastric fundus to acetylcholine in organ bath between groups

Groups	Mean (SD)	*P*-value	Critical level
1-2	0.52 (1.1)	0.18	0.01
1-3	0.65 (1.41)	0.07	0.01
1-4	0.83 (1.64)	0.06	0.01
2-3	0.35 (0.86)	0.41	0.02
2-4	0.44 (0.98)	0.29	0.02
3-4	0.09 (0.25)	0.92	0.05

SD: Standard deviation

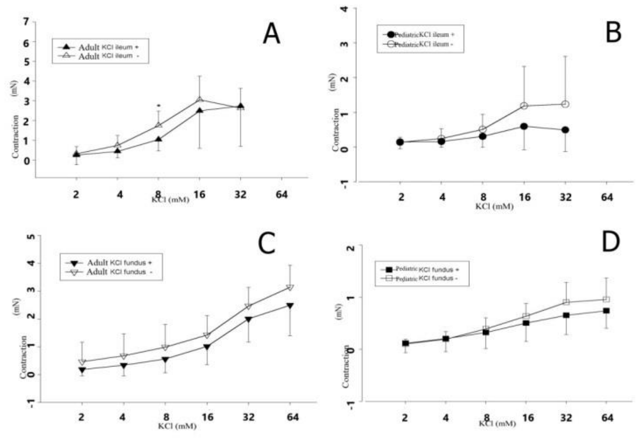

Figure 1: Comparison of cumulative potassium chloride responses in the ileum (A and B) and fundus (C and D) in adult and pediatric groups. Laparoscopy (+), Laparotomy (-)

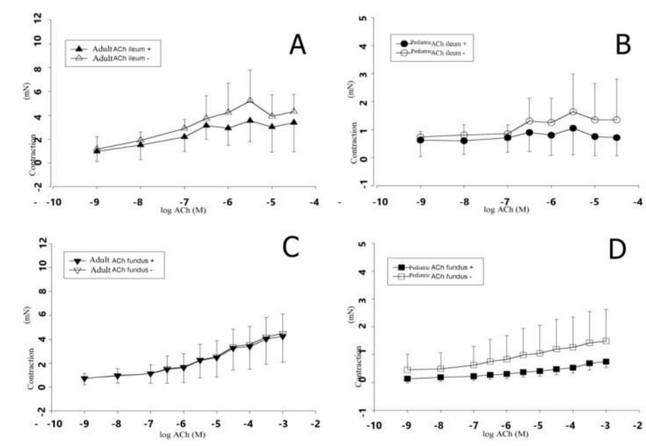

Figure 2: Comparison of cumulative acetylcholine responses in the ileum (A and B) and fundus (C and D) in adult and pediatric groups. Laparoscopy (+), Laparotomy (-)

Discussion

It has been shown that increasing the pressure of pneumoperitoneum from 10 mmHg to 20 mmHg in the pig model reduces mucosal blood flow in the small intestine by 20% to 40% [3]. In the study performed in rats, pneumoperitoneum with up to 20-25 mmHg was reported to cause a 63% decrease in mucosal blood flow [4]. Intraabdominal pressure between 10-15 mmHg in rats reportedly caused a reduction on jejunal mucosal perfusion and consequently caused severe damage to mucosal microcirculation [5]. GIS hypoxia related to high IAP may damage the neuronal structures, which release the neurotransmitters responsible for induction of intestinal contractility and motility [2]. Although those experimental studies have pointed out that high IAP may cause GIS mucosal damage and motility disorders, some other studies have shown that pneumoperitoneum during laparoscopy is not detrimental to GIS motility [6-8]. In most of the laparoscopic procedures, the level of IAP is well tolerated, but variables such as age and size of the patient, level of gas pressure and flow rate and duration of pneumoperitoneum should be considered. In this study, the variables were age and size. Under constant insufflation pressure, flow rate and duration, the effect of pneumoperitoneum on gastric and intestinal motility was investigated for both pediatric and adult ages.

Our results showed that the lowest contraction response for both the stomach and intestine was in group 1 and the contraction responses in both pediatric pneumoperitoneum and laparotomy groups were non-significantly lower than the adult groups. We may hypothesize that lower contraction response might be related to anesthesia and the physiologic stress of the surgery in pediatric groups. Midazolam in combination with ketamine was administered for surgical anesthesia. Ketamine hydrochloride and midazolam may prolong oro-cecal transit time and decrease GIS contractility [9,10]. Findings in our study may suggest that ketamine hydrochloride and midazolam were more effective on motility in pediatric age groups than adult groups. Surgical stress also alters GIS motor function [11,12]. Physiological stress due to surgery might be another factor triggering lower contraction responses in the pediatric groups.

Pneumoperitoneum was best tolerated at a pressure of 2 mmHg and flow rate of 0.5 L/minutes for a model of neonatal minimally invasive surgery in rats [13]. In our study, 5 mmHg of pressure was well tolerated, and the procedure could be completed in Group 1. This may suggest that IAP might be increased up to 5 mmHg in future studies on pediatric rat models.

Our gastric and ileal motility studies showed that the difference in contraction responses between the pediatric and adult pneumoperitoneum groups at the same pressure, flow rate and duration, and that between the pneumoperitoneum and laparotomy groups, were non-significant. These results may suggest that pneumoperitoneum does not adversely affect gastric and small intestinal motility in pediatric age groups. However, this study has some limitations. Further randomized controlled studies should be designed to measure contraction responses at different ages, weights, types of anesthesia, intra-abdominal pressure levels, and operative durations. The effects of pneumoperitoneum on GIS motility in different intraabdominal surgical procedures of children should also be investigated.

References

1. Jimbo T, Masumoto K, Takayasu H, Shinkai T, Urita Y, Uesugi T, et al. Outcome of early discharge protocol after appendectomy for pediatric acute appendicitis. Pediatr Int. 2017;59(7):803-6.
2. Ünsal A.M, İmamoğlu M, Kadioğlu M. The Acute Alterations in Biochemistry, morphology and contractility of rat-isolated terminal ileum via increased intra-abdominal pressure. Pharmacological Research. 2006;53:135-41.
3. Goitein D, Papasavas P, Yeaney W, Gaqne D, Hayetian F, Caushaj P, et al. Microsphere intestinal blood flow analysis during pneumoperitoneum using carbon dioxide and helium. Surg Endosc. 2005;19:541-5.
4. Diebel LN, Dulchavsky SA, Brown WJ. Splanchnic ischemia and bacterial translocation in the abdominal compartment syndrome. J Trauma. 1997;43:852-5.
5. Samel ST, Neufang T, Mueller A, Leister I, Becker H. New abdominal cavity champer to study the impact of increased intraabdominal pressure on microcirculation of gut mucosa by using video microscopy in rats. Crit Care Med. 2002;30:1854-8.
6. Ludwig KA, Frantzides CT, Carlson MA, Grade KL. Myoelectric motility patterns following open versus laparoscopic cholecystectomy. J Laparoendosc Surg. 1993;3:461-6.
7. Naito T, Garcia-Luiz A, Vladisavljevic A, Matsuno S, Gagner M. Gastrointestinal transit and stress response after laparoscopic vs conventional distal pancreatectomy in the canin model. Surg Endosc. 2002;16:1627-30.
8. Hotokezaka M, Dix J, Mentis EP, Schirmer BD. Gastrointestinal recovery after laparoscopic vs open colon surgery. Surg Endosc. 1996;10:485-9.
9. Sparkes AH, Papasouliotis K, Viner J, Cripps PJ, Gruffydd-Jones TJ. Assessment of orocaecal transit time in cats by the breath hydrogen method: the effects of sedation and a comparison of definitions. Res Vet Sci. 1996;60:243-6.
10. Inada T, Asai T, Yamada M, Shingu K. Propofol and midazolam inhibit gastric emptying and gastrointestinal transit in mice. Anesth Analg. 2004;99(4):1102-6.
11. Taché Y, Martinez V, Million M, Wang L. Stress and the gastrointestinal tract III. Stress-related alterations of gut motor function: role of brain corticotropin-releasing factor receptors. Am J Physiol Gastrointest Liver Physiol. 2001;280(2):173-7.
12. Caso JR, Leza JC, Menchén L. The effects of physical and psychological stress on the gastro-intestinal tract: lessons from animal models. Curr Mol Med. 2008;8(4):299-312.
13. Mayer S, Peukert N, Gnatzy R, Gosemann JH, Lacher M, Suttkus A. Physiologic Changes in a Small Animal Model for Neonatal Minimally Invasive Surgery. J Laparoendosc Adv Surg Tech A. 2018;28(7):912-7.

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The National Library of Medicine (NLM) citation style guide has been used in this paper.

Suggested citation: Patrias K. Citing medicine: the NLM style guide for authors, editors, and publishers [Internet]. 2nd ed. Wendling DL, technical editor. Bethesda (MD): National Library of Medicine (US); 2007-[updated 2015 Oct 2; cited Year Month Day]. Available from: http://www.nlm.nih.gov/citingmedicine