

Establishing an Artificial Pneumoperitoneum for Laparoscopic Procedures

Criação do Pneumoperitônio Artificial para a Realização de Procedimentos Videolaparoscópicos

JOÃO LUIZ MOREIRA COUTINHO DE AZEVEDO

*Associate Titular Professor of the Department of Surgery of the Escola Paulista de Medicina (EPM)
of the Federal University of São Paulo (UNIFESP).*

ABSTRACT

The studies conducted by our study group in the field of video-assisted surgery have contributed to a deeper understanding of the creation of pneumoperitoneum for laparoscopic procedures. The occurrence of morbid, sometimes fatal, events while establishing a pneumoperitoneum by insertion of a Veres needle encouraged us to conduct a systematic review of the literature regarding this issue. This review revealed that Veres needle insertion into the abdominal cavity through a midline incision can result in injury to viscera and great retroperitoneal vessels, as well as a large number of deaths. This procedure is performed by most laparoscopic surgeons in Brazil and the USA. In an attempt to find safer alternatives, we conducted experimental and clinical studies in which the Veres needle was inserted into the left hypochondrium. There have been no reports of injury caused by Veres needle insertion into the left hypochondrium.

Key words: Artificial pneumoperitoneum; Laparoscopy, laparoscopic complications; Pneumoperitoneum; Veres needle Puncture.

Bras. J. Video-Sur, 2011, v. 4, n. 1: 035-041

—Accepted after revision: December, 12, 2010.

INTRODUCTION

We initially investigated this technique in a study involving experimental animals (pigs), with the participation of an undergraduate student who was the recipient of a Young Investigator grant. With the aid of two doctoral students, we subsequently conducted clinical studies that resulted in academic dissertations. One of these involved a sample that was representative of a specific population, and other involved a sample that was representative of the general population. These studies demonstrated that the insertion of a Veres needle into the left hypochondrium to establish an artificial pneumoperitoneum is a viable, efficacious, and effective technique. Therefore, we began to recommend that laparoscopic surgeons adopt this technique, since it is theoretically safer than Veres needle insertion through a midline incision.

Next, we conducted studies that aimed to evaluate the accuracy of the five tests that are most commonly used to determine whether the tip of the Veres needle is indeed inside the peritoneal cavity

before proceeding with CO₂ insufflation. In addition to determining the true diagnostic value of these tests, we attempted to establish at certain time points during insufflation a relationship between the following parameters: gas flow; intraperitoneal pressure; and the volume of gas injected into the peritoneal cavity. We found that pressure and volume was strongly correlated at certain time points during insufflation and that intraperitoneal pressure strongly correlated with volume. These findings allowed us to devise tables containing values of volume and pressure as a function of time, as well as expected values of pressure as a function of volume (and vice-versa), with the purpose of guiding surgeons during the process of intraperitoneal insufflation.

In addition, by applying the fuzzy set theory, we developed, in collaboration with other researchers from the *Universidade Federal de São Paulo* (UNIFESP, Federal University of São Paulo), São Paulo, Brazil, a computer program (for which we have filed a patent application) including a mathematical model, that can provide insufflators with a safety device

during the process of establishing a pneumoperitoneum using the closed technique.

Still regarding the safety of the process of creation of pneumoperitoneum, we studied the critical moment of insertion of the first trocar after creation of pneumoperitoneum through the closed technique (that is, without peritoneotomy), as well as measures to improve the safety of the procedure. With regard to the latter, we conducted a study that demonstrated that high intraperitoneal pressures (20 mmHg) for a short period of time (5 min) had no adverse effects on patients. This transitory increase in pressure was proposed by the authors with the purpose of increasing the distance between the anterior abdominal wall and the contents of the abdominal cavity, in order to avoid iatrogenic injury to important intra-abdominal structures when the first trocar is blindly inserted. We now consistently recommend the use of this measure. We are currently evaluating the effects of transitory, high intraperitoneal pressure on obese patients, who are known to be more prone to develop compartmental syndrome under these conditions. These studies aim to determine the highest intraperitoneal pressure level that has no negative effect on the patient, as well as the resulting volume of gas.

Finally, our goal has been to use modern and effective teaching methods, such as interactive computer programs and virtual reality, for teaching the safest, most effective way of establishing a pneumoperitoneum for laparoscopic procedures.

The line of research designated "Creation of artificial pneumoperitoneum for laparoscopic procedures" is within the field of video-assisted surgery.

The majority of complications associated with videolaparoscopy occur during the most critical step, which is the access to the peritoneal cavity,¹ because of the significant risk of vascular and visceral injuries.²

Addressing this particular issue, we conducted a recent systematic review,³ selecting 38 articles that encompassed 696,502 laparoscopies. 1,575 (0.23%) lesions were reported, of which 126 (8%) involved blood vessels or hollow viscera (prevalence of 0.018% of the laparoscopies). Of the 98 vascular lesions, 8 (8.1%) were major retroperitoneal vessels of the midline. We concluded from this systematic review that puncture with a Veres needle in the midline of the abdomen, at the level of the umbilical scar, poses important risks for the life of the patients, and that

there should be studies of alternative locations for this type of puncture.

Reports of litigation because of medical errors related to videolaparoscopy suggest that 18% of the complaints occurred due to accidents in the course of establishing the pneumoperitoneum, and close to half of all laparoscopic complications were attributed to technical problems that occurred in this step of the procedure.⁴

Vascular injuries represent the most common cause of death in laparoscopic procedures (15%). Injuries of the great retroperitoneal vessels can occur when the Veres needle is blindly inserted into the abdomen, before insufflation, as occurs in the closed technique.²

In general, there are two techniques to establish a pneumoperitoneum and access the peritoneal cavity. The first is called "closed" or "blind", and is performed using a Veres needle, followed by the insertion of the trocar, or, less often, by direct insertion of the trocar without pneumoperitoneum.⁵ The second method is the open technique, in which a small laparotomy is performed under direct vision in the umbilical region, followed by introduction of the blunt trocar (Hasson's trocar).⁶

Although there is no consensus regarding the best method for accessing the peritoneal cavity in order to establish the pneumoperitoneum,⁷ puncture with the Veres needle⁸ is the most frequently used technique.³⁵⁻³⁷ The study considered 155,987 laparoscopic procedures; in 81% a Veres needle was used.^{8,9}

The Veres needle was developed in 1938 by the Hungarian physician János Veres for the purpose of establishing a pneumothorax to partially collapse the lung as a treatment for tuberculosis.⁹ Today the Veres needle is used to create a path of entry into the abdominal cavity to establish a pneumoperitoneum for the purpose of making possible laparoscopic procedures.¹⁰

Commercially available Veres needles vary from 12 to 15 cm in length, with an external diameter of 2 mm. A bezel-shaped tip enables the needle to pierce the tissues of the abdominal wall. Upon entering the peritoneal cavity, the resistance generated from the abdominal wall is overcome, which permits the exposure of the interior needle with its blunt atraumatic mandril.¹¹ This system affords a degree of safety and efficacy, making the puncture of the peritoneal cavity with a Veres needle an easy, fast and effective technique. Once the peritoneal cavity is inflated by this technique, the first trocar can be inserted without

problems, minimizing intraoperative gas leakage and saving surgical time.

Nevertheless, despite this safety device, incorrect insufflations occur. Injuries to major vessels are the leading intraoperative cause of death associated with laparoscopic procedures.¹² There are case reports of injuries to major vessels that show all the drama of the situation.^{13,14} The timely diagnosis of this complication is extremely difficult, mainly because of the position of the retroperitoneal vessels.¹⁵

The classic location of the Veres needle puncture is the midline of the abdomen near the umbilical scar.¹⁶ Due to the short distance between the anterior abdominal wall and the retroperitoneal vascular structures in this region – less than two centimeters in thin people – puncture poses risks of injury to these large vessels.¹⁷ The abdominal aorta, the inferior vena cava, as well as the common iliac vessels are especially vulnerable to lesions during puncture with the Veres needle in proximity of the umbilical scar.¹⁵

Injuries to these vessels are serious complications of laparoscopy that can occur in a blind moment of the laparoscopy, such as when puncturing to establish the pneumoperitoneum: “Certainly one of the most dramatic events that a surgical team can experience is a major vascular injury. Although the prevalence of these occurrences is very low (0.05%), the mortality associated with them ranges from 8% to 17%”.¹⁸

Although effective, the midline puncture poses dangers. All injuries of large intra-abdominal retroperitoneal vessels by Veres needle, reported in the literature, were caused by midline punctures performed close to the umbilical scar. Due to the location of these large vessels, it is legitimate to assume that the risk of associated injuries is minimized when the punctures are done in a location away from the midline.^{19,20}

Additionally, patients who have undergone previous abdominal surgery are at increased risk of visceral lesions associated with the Veres needle because of peritoneal adhesions, which typically are located at the level of the scar from the surgical incision of the anterior parietal peritoneum.²¹ Autopsy studies found adhesions in 74% to 95% of patients with prior abdominal surgeries.¹⁸ The midline incisions are those that pose the greatest risk of adhesion around the umbilical scar. Nevertheless, even abdominal incisions somewhat distant from the navel may still

result in the formation of adhesions in the periumbilical region.¹⁸

In contrast, puncturing the left upper quadrant has been described as being safe, without risk of a major iatrogenic injury.^{19,20} The specific point is the predominant anatomical structure in the left hypochondrium/upper quadrant^{19,20} and the occasional injuries are generally minor.

The organs immediately behind the anterior abdominal wall at the puncture site of the left upper quadrant are the stomach and transverse colon.²¹ In the event that the stomach is accidentally injured by the Veres needle, gastric contents would not necessarily escape, because the action of the triple layer of muscle of the stomach walls tends to occlude any puncture hole. In the event of accidental insufflation of the lumen of the gastric body, the gas escaping through the orogastric tube will be evident and will reveal the situation. In order to minimize the risk of injuries to the small intestine and the colon from punctures in the upper left quadrant with the Veres needle, patients should be placed in reverse Trendelenburg position of about 20 degrees, so that small bowel loops and segments of the transverse and descending colon can migrate to the temporarily elevated lower floor of the abdomen. Keep in mind that such lesions – both in the colon and in the stomach – are easy to diagnose upon initial inspection of the peritoneal cavity, and can be repaired laparoscopically by means of a suture stitch.

The rarity of adhesions in the abdominal wall of the left upper quadrant of the region should also be taken into consideration. As it is known that the respiratory movements of the diaphragm constantly mobilize structures in this region, and thus hinder their fixation to the anterior abdominal wall, the puncture of the left upper quadrant is the approach preferred by some surgeons for patients who have undergone prior laparotomy.²²

There are also surgeons who perform bariatric surgeries and prefer the left upper quadrant for the installation of pneumoperitoneum in their patients.²¹ This preference is due to the fact that in obese patients the open technique poses additional difficulties because of the excess weight, and puncture in the midline is dangerous due to the thickness of the adipose tissue and the high position of the navel in the abdomen. These characteristics make it difficult to puncture and facilitate injuries, most notably of the large retroperitoneal vessels.²²

It is worth noting that the lesions, both vascular and visceral, produced by the blind introduction of Veres needle and trocars in the midline of the abdomen, are not prerogatives of inexperienced surgeons. Schafer et al. (2001)²³ found that among 26 such lesions, only four (15%) were produced by inexperienced surgeons (those who had performed fewer than 50 laparoscopies), while in 22 lesions (85%) the laparoscopies were performed by experienced observers (those who had performed between 51 and 100 laparoscopies) or very experienced (over 100 laparoscopies performed).

In terms of safety and efficacy, there are real advantages in the puncture of the left upper quadrant relative to the midline puncture. We proved this by research, first in experimental animals.²⁴

In these animals (pigs) – whose abdominal anatomy is very similar to the human – we found that at the level of the arch formed by the costal cartilages (lower rib cage) the parietal peritoneum is closely adhered to the transverse fascia, and this ensemble is attached to with the costal cartilages. This configuration confers a certain some degree of fixity of the parietal peritoneum at this level, which is why we chose to standardize the location close to the edge of the lower rib cage as the puncture site we propose for the left upper left quadrant.

The idea is to minimize the possibility that the tip of Veres needle mistakenly remains in the space between the parietal peritoneum and transversalis fascia without entering the peritoneal cavity. Thus, we modified the location of the puncture as described by Palmer (a site two fingerbreadths below the rib cage) to a site close to the rib cage, in an experimental trial in humans.^{25,26}

It is also imperative that during puncture one knows with the highest degree of precision possible the real location of the needle before initiating insufflation; proof of the needle's position is recommended in textbooks. There was a need to perform original research to assess the real value of these tests to confirm the needle's position, both in selected populations²⁷ and in the general population.²⁸

Moreover, in order to inform the surgeon during the insufflation, it is interesting to consider that the levels of intraperitoneal pressure and the total volume injected at certain points of the insufflation are objective data, and their values can be correlated with the presence or absence of the tip of the Veres needle inside the peritoneal cavity at certain points of

the insufflation process. This research was carried out by us.²⁹

It is also useful to be able to directly correlate the intraperitoneal pressure with the volumes actually injected. We have conducted research studying these issues.^{30,31}

All this research accumulated data that were used by us in developing a computer program using artificial intelligence (fuzzy logic). In conjunction with the Federal University of São Paulo (UNIFESP) a patent application has been submitted entitled:

“Diffuse system of decision support for positioning/placement of the Veres needle in the peritoneal cavity during the procedure for creating an artificial peritoneum, with input variables, volume and pressure, and variable output flow.”

In addition, in the context of teaching the techniques for establishing an artificial pneumoperitoneum, we developed a computer program that was tested as part of doctoral dissertation,³² with the results subsequently published in a journal.³³

An automated demonstration of the operation of this interactive program is available on the Web at the URL: http://www.cirurgiaonline.med.br/cursos/simulador_demonstracao.

In another vein, still aimed at the prevention of such iatrogenic events, research by my group was done considering that the establishment of a regimen of very high pneumoperitoneum pressure, for just enough time to introduce the first trocar – done blindly using the closed method – could help to protect the intra-abdominal structure from injuries without, however, causing organic repercussions in the form of clinical complications.³⁴⁻³⁷ In this particular regard, the results of other authors,³⁸ were confirmed by ours.

Measures aimed at promoting the safety of establishing a pneumoperitoneum were evaluated and have been routinely used by video-laparoscopists. The measures include definitions regarding the type of gas to be used, the anatomic site and procedure for safe puncture with a Veres needle, injuries caused by the Veres needle, conducting tests to ensure proper placement of the needle, the diagnostic value of intraperitoneal pressure as it relates to injected volumes, precautions for the blind introduction of the first trocar, by direct view, according to Hasson, or with an optic trocar.

There is no study establishing a maximum volume of the intra-abdominal workspace or pressure

levels corresponding to normal pressure levels. Given that any pressure increase – even those that fall within safety margins – causes repercussions if the surgical interventions are prolonged, the ideal would be to establish for each patient their normal intraperitoneal pressure, even without curarization, and thereby establish the value for their pneumoperitoneum.

This is research that we are initiating (*Artificial pneumoperitoneum and systemic repercussions: correlation between intra-abdominal pressure and intraperitoneal space actually created.*) It proposes to study what is the lowest intraperitoneal pressure that provides the maximum immutable space, even with a subsequent increase in pressure, according to the anthropometric characteristics of each patient.

Laparoscopic surgery has presented the anesthesiologist with many questions about how pneumoperitoneum and the positioning of the patient

affect the cardiorespiratory system. As they pertain to patients of normal weight, most changes in cardiorespiratory dynamics have been studied, but few clinical trials have been conducted in order to evaluate the effects of pneumoperitoneum on the morbidly obese.

Our group is conducting another research project: “*Organic implications of transient elevation of pneumoperitoneum pressure in laparoscopic metabolic and bariatric surgery to prevent iatrogenic injuries during the introduction of the first trocar in the morbidly obese.*”

The objective of this study is to evaluate the safety of laparoscopic bariatric surgery, as well as the clinical, hemodynamic, gasometrical, and metabolic implications of artificial pneumoperitoneum in the morbidly obese. The study also aims to define the best level of intra-abdominal pressure compatible with this technique in this patient population.

RESUMO

Com o auxílio das pesquisas do nosso grupo sobre o tema conseguimos agregar ao conhecimento da videocirurgia uma contribuição importante sobre a criação do pneumoperitônio artificial para procedimentos videolaparoscópicos. Alertados pela ocorrência de eventos mórbidos, às vezes fatais, durante o estabelecimento do pneumoperitônio mediante punção com agulha de Veres, realizamos análise sistemática da literatura em relação a este tema, quando constatamos que lesões viscerais e de grandes vasos retroperitoneais ocorrem por causa da punção abdominal na linha mediana, com muitos óbitos. Este tipo de punção é realizado no Brasil e nos Estados Unidos pela grande maioria dos cirurgiões laparoscopistas. Buscando alternativas mais seguras, realizamos estudos experimentais e clínicos com punção no hipocôndrio esquerdo, com a qual não há relatos de lesões.

Palavras-chave: Pneumoperitônio artificial; Laparoscopia; Complicações laparoscópicas; Pneumoperitônio; Punção com agulha de Veres.

REFERENCES

- Anaise. D, editor. Vascular and bowel injuries during laparoscopy [monography of the Internet]. Available from: http://www.danaise.com/vascular_and_bowel_injuries_duri.htm
- Neudecker J, Sauerland S, Neugebauer E, Bergamaschi R, Bonjer HJ, Cuschieri A, Fuchs K-H, Jacobi Ch, Jansen FW, Koivusalo A-M, Lacy A, McMahon MJ, Millat B, Schwenk W. The European Association for Endoscopic Surgery clinical practice guideline on the pneumoperitoneum for laparoscopic surgery. *Surg Endosc.* 2002;16:1121-43.
- Azevedo JLMC, Azevedo O, Miyahira SA, Miguel GPS, Becker Júnior OM, Hypólito OHM, Machado ACCG, Córdia W, Yamaguchi GA, Godinho L, Freire D, Almeida CES, Moreira CH. Injuries caused by Veres needle insertion for creation of pneumoperitoneum: a systematic literature review. *Surg Endosc.* 2009; 23:1428-32. DOI: 10.1007/s00464-009-0383-9
- Hasan A, Banli O, Kavlakoglu B. Comparison between direct trocar and Veres needle insertion in laparoscopic cholecystectomy. *J Laparoendosc & Adv Tech.* 2007; 17:709-12.
- Hasson HM. A modified instrument and method for laparoscopy. *Amer J Obstet Gynec.* 1971; 110:887-7.
- Molloy D, Kaloo PD, Cooper M, Nguyen TV. Laparoscopic entry: a literature review and analysis of techniques and complications of primary port entry. *Aust N Z J Obstet Gynaecol.* 2002; 42:246-53.
- Bridgewater FH, Mouton WG. Rationale and intended use for the Veres needle: a translation of the original descriptive article. *Surg Laparosc Endosc.* 1999; 9:241-4.

8. Veres J. Neues Instrument zur Ausfuehrung von Brust-oder Bauchpunktionen und Pneumothoraxbehandlung. *Dtsch Med Wochenshr.* 1938; 41:1480-1.
9. Santor J, Ballagi F, Nagy A, Rákóczi I. A needle-puncture that helped to change the world of surgery. *Surg Endosc.* 2000; 14:201-2.
10. Fitzgibbons RJ, Marsh RE. Métodos para a criação de um pneumoperitônio. In: Zucker KA, editors. *Videocirurgia*, 2nd ed. Rio de Janeiro: Revinter; 2006. p. 29-39.
11. Chandler JG, Corson SL, Way LW. Three spectra of laparoscopic entry access injuries. *J Am Coll Surg.* 2001; 192:478-91.
12. Peterson HB, Greenspan JR, Ory HW. Death following puncture of the aorta during laparoscopy sterilization. *Obstet Gynecol.* 1982; 59:133-4.
13. Hanney RM, Kathryn AM, Cregan PC. Major vascular injury and laparoscopy. *Aust N Z J Surg.* 1995; 65:533-5.
14. Pirró N, Ciampi D, Champsaur P et al. The anatomical relationship of the iliocava junction to the lumbosacral spine and the aortic bifurcation. *Surg Radiol Anat.* 2005; 27:137-41.
15. Guimarães P. Pneumoperitônio, punções e trocartes. In: Donadio N, Albuquerque Neto LC. Eds. *Consenso Brasileiro em videoendoscopia ginecológica*. São Paulo, Artes Médicas, 2001. p.27-32.
16. Hurd WW, Bude RO, DeLancey JOL, Pearl ML. The relationship of the umbilicus to the aortic bifurcation: implications for laparoscopic technique. *Obstet Gynecol.* 1992; 80:48-51.
17. Roviario GC, Varoli F, Saguatti L, Vergani C, Maciocco M, Scarduelli A. Major vascular injuries in laparoscopic surgery. *Surg Endosc.* 2002;16:1192-6.
18. Palmer R. Safety in laparoscopy. *J Reprod Med.* 1974;13:1-5.
19. Rohatgi A, Widdison AL. Left Subcostal Closed (Veres Needle) Approach Is a Safe Method for Creating a Pneumoperitoneum. *J Laparoendosc Adv Surg Tech.* 2004; 14:278-80.
20. Catarci M, Carlini M, Gentileschi P, Santoro E. Major and minor injuries during the creation of pneumoperitoneum. *Surg Endosc.* 2001; 15:566-9.
21. Schwartz ML, Drew RL, Andersen JN. Induction of pneumoperitoneum in morbidly obese patients. *Obes Surg.* 2003;13:601-4.
22. Schafer M, Lauper M, Krahenbuhl. Trocar and Veres needle injuries during laparoscopy. *Surg Endosc.* 2001; 15:275-80.
23. Azevedo JLMC, Guindalini RSC, Sorbello AA, Silva CEP, Azevedo OC, Aguiar GS, Menezes FJC, Delorenzo A, Pasqualin RC, Koza FO. Evaluation of the positioning of the tip of the Veres needle during the creation of the pneumoperitoneum by using the closed technique, in pigs. *Acta Cir Bras, São Paulo.* 2006; 21:26-30. DOI: 10.1590/S0102-86502006000100007
24. Azevedo OC. Punção no hipocôndrio esquerdo na criação do pneumoperitônio: valor diagnóstico das provas de posicionamento da agulha de Veres, das pressões intraperitoneais e dos volumes injetados durante a insuflação. Tese (Doutorado). Universidade Federal de São Paulo. Escola Paulista de Medicina. São Paulo, 2006. 52f.
25. Azevedo OC, Azevedo JLMC, Miguel GPS, Guindalini RSC. Veres needle insertion in the left hypocondrium in creation of the pneumoperitoneum. *Acta Cir Bras, São Paulo.* 2006; 21:296-303. DOI: 10.1590/S0102-86502006000500005
26. Azevedo OC, Azevedo JLMC, Sorbello AA, Miguel GPS, Wilson Junior JL, Godoy AC. Evaluation of tests performed to confirm the position of the Veres needle for creation of pneumoperitoneum in selected patients: a prospective clinical trial. *Acta Cir Bras. São Paulo.* 2006; 21:385-91. DOI:10.1590/S0102-86502006000600006
27. Becker JOM, Azevedo JLMC, Hypólito OHM, Miyahira SA, Miguel GPS, Machado ACCG, Azevedo O. Veres needle insertion into the left hypocondrium for creation of pneumoperitoneum: diagnostic value of tests to determine the position of the needle in a random population. *Rev Col Bras Cir.* 2010.
28. Azevedo JLMC, Azevedo OC, Sorbello AA, Becker OM, Hypólito O, Freire D, Miyahira S, Guedes A, Azevedo GC. Intraperitoneal pressure and volume of gas injected as effective parameters of the correct position of the Veres needle during creation of pneumoperitoneum. *J Laparoendosc Adv Surg Tech. Part A, Online Ahead of Print: September 30, 2009.* DOI: 10.1089/lap.2009.0080.
29. Becker JOM. Criação do pneumoperitônio no hipocôndrio esquerdo: sistema nebuloso (fuzzy) de suporte de decisão pela relação pressão/volume do posicionamento da ponta da agulha de Veres. Tese (Doutorado). Universidade Federal de São Paulo. Escola Paulista de Medicina. São Paulo, 2008. 89f.
30. Becker JOM, Araújo E, Azevedo JLMC. Laparoscopy pneumoperitoneum fuzzy modeling. *IEEE Transactions on Biomedical Engineering (Print).* 2010.
31. Oliveira EFB. Eficácia de um simulador multimídia no ensino de técnicas básicas de videocirurgia para alunos do curso de graduação. Tese (Doutorado). Universidade Vale do Rio Verde de Três Corações. Minas Gerais, 2005. 51f.
32. Oliveira EFB, Azevedo JLMC, Azevedo OC. Eficácia de um simulador multimídia no ensino de técnicas básicas de videocirurgia para alunos do curso de graduação em medicina. *Rev Col Bras Cir.* 2007; 34:251-6. DOI: 10.1590/S0100-69912007000400010
33. Hypólito OHM. Repercussões orgânicas da manobra de elevação para 20mmHg da pressão do pneumoperitônio artificial durante cinco minutos visando à prevenção de lesões iatrogênicas na introdução do primeiro trocarte: ensaio clínico e randômico. Tese (Doutorado). Universidade Federal de São Paulo. Escola Paulista de Medicina. São Paulo, 2008. 64f.
34. Hypólito OHM, Azevedo JLMC, Caldeira FMSLA, Azevedo OC, Miyahira SA, Miguel GPS, Becker Jr OM, Guedes

- ACC. Creation of pneumoperitoneum: noninvasive monitoring of clinical effects of elevated intraperitoneal pressure for the insertion of the first trocar. *Surgical Endoscopy*. 2010; 24:1663. DOI:10.1007/s00464-009-0827-2.
35. Hipólito OHM, Azevedo JLMC, Gama FAB, Azevedo OC, Becker Júnior OM, Machado ACCG, Miyahira SA, Azevedo GC. Invasive monitoring of the clinical effects of high intra-abdominal pressure for insertion of the first trocar in laparoscopy. *J Chir*. 2010.
36. Hipólito OHM, Azevedo JLMC, Gama FAB, Azevedo OC, Becker Júnior OM, Machado ACCG, Miyahira SA, Azevedo GC. Relação do CO₂ arterial e expirado na pressão do pneumoperitônio artificial elevada para a introdução do primeiro trocarte. 2010.
37. Reich H, Ribeiro SC, Rasmussen C, Rosenberg J, Vidali A. High-pressure trocar insertion technique. *J Soc Laparoendosc Surg*. 1999; 3:45-8.
38. Reich H, Rasmussen C, Vidali A. Peritoneal hypertension for trocar insertion. *Gynaecol Endosc*. 1999; 8:375-7.
39. Tsaltas J, Pearce S, Lawrence A, Meads A, Mazzatesta J, Nicolson S. Safer laparoscopic trocar entry: its all about pressure. *Aust N Z J Obstet Gynaecol*. 2004; 44:349-50.

Correspondence Address:

JOÃO LUIZ MOREIRA COUTINHO DE AZEVEDO

R. Joaquim Távora 550 – Apto 101-A

V. Mariana – CEP 04015-011

São Paulo, SP