

# High-pressure laparoscopic entry does not adversely affect cardiopulmonary function in healthy women

Basim Abu-Rafea, MD, George A. Vilos, MD, Angelos G. Vilos, Hon BSc, Riad Ahmad, MD, Jackie Hollett-Caines, MD, and Mohamad Al-Omran, MD

From the Department of Obstetrics and Gynecology, St. Joseph's Health Care, The University of Western Ontario, London (Drs. Abu-Rafea, G. Vilos, A. Vilos, Ahmad, and Hollett-Caines); and Department of Surgery, University of Toronto, Toronto (Dr. Al-Omran), Ontario, Canada.

## KEYWORDS:

Laparoscopy;  
High-pressure entry;  
Hyperinsufflation;  
Pneumoperitoneum;  
Pulmonary  
compliance;  
Hemodynamic  
changes

## Abstract

**STUDY OBJECTIVE:** To determine hemodynamic and pulmonary compliance changes during laparoscopic entry using transient hyperinsufflated pneumoperitoneum.

**DESIGN:** Prospective observational cohort study (Canadian Task Force classification II-1).

**SETTING:** University-affiliated teaching hospital.

**SUBJECTS:** From January through June 2004 one hundred healthy women underwent operative laparoscopy consecutively. Indications included chronic pelvic pain (CPP, N = 66), pelvic mass (N = 7), CPP and pelvic mass (N = 4), primary or secondary infertility (N = 23). The mean age was 34 years (range, 19-58) and the mean BMI 25.5 kg/m<sup>2</sup> (range, 17.1-39.4).

**INTERVENTIONS:** With the patients under general anesthesia, muscle relaxants, and in supine position, pneumoperitoneum was established using a Veres needle. The following information was prospectively collected at different intraperitoneal insufflation pressures (IPIP): CO<sub>2</sub> volume, heart rate, blood pressure, and pulmonary compliance. At IPIP of 30 mm Hg the primary trocar was inserted and the IPIP was immediately reduced back to the operating pressure of 15 mm Hg.

**MEASUREMENTS AND MAIN RESULTS:** The mean initial IPIP was 4.7 mm Hg (range, 2-9 mm Hg). The mean volume of CO<sub>2</sub> at IPIP of 10, 15, 20, 25, and 30 mm Hg was 1.7, 3.1, 4, 4.4, and 4.7 L, respectively. There was no statistically significant change in the heart rate or pulse pressure between IPIP of 15 and 30 mm Hg. The difference in CO<sub>2</sub> volume (1.6 L) required to achieve IPIP of 15 and 30 mm Hg was statistically significant ( $p < 0.0001$ ). A statistically significant increase of 7 mm Hg in the mean arterial pressure (MAP) was found between IPIP of 15 & 30 mm Hg ( $p < 0.0001$ ). The additional 21% drop in pulmonary compliance from IPIP 15 to 30 mm Hg was statistically significant ( $p < 0.0001$ ). This decrease in pulmonary compliance was well tolerated by the patients, and the oxygen saturation remained above 92% in all cases. The elevated MAP was not clinically significant.

**CONCLUSION:** The use of transient hyperinsufflated pneumoperitoneum caused minor hemodynamic alterations which were not clinically significant. The alterations in pulmonary compliance were statistically significant; however, they had no clinical significance and were tolerated well by healthy women.

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Corresponding author: Basim Abu-Rafea, MD, Department of Obstetrics and Gynecology, St. Joseph's Health Care, 268 Grosvenor Street, London, Ontario, Canada N6A 4V2.

E-mail: baburafea@gmail.com

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The majority of laparoscopic complications occur during entry into the abdomen; the most significant being injuries to the gastrointestinal tract and major blood vessels. This makes laparoscopy the only surgical procedure in which at least 50% of complications occur before the intended surgery commences.<sup>1,2</sup>

During the last 50 years, a fool-proof or risk-free laparoscopic entry technique has remained elusive, and no consensus exists as to the safest method.<sup>3-5</sup> Several techniques and instruments have been explored in order to minimize entry-related injuries.<sup>3,5-7</sup> Among these techniques, peritoneal hyperdistention was described in 1999.<sup>8,9</sup> This technique requires the insertion of a Veres needle and insufflation of the peritoneal cavity to a pressure of as much as 25–30 mm Hg before the insertion of the primary trocar.

The rationale for the high intraabdominal pressure is that it produces a greater splinting of the abdominal wall and a deeper intraabdominal gas bubble than the traditional volume-limited pneumoperitoneum of 2 to 4 L, allowing for safer trocar insertion. The pressure is immediately reduced to 15 mm Hg once entry is confirmed.<sup>2,7-10</sup>

Although a previous study demonstrated no detrimental cardiopulmonary effects in patients,<sup>10</sup> the high-pressure technique has not gained popularity. One possible reason is the notion that high intraperitoneal pressures before primary trocar insertion adversely affect cardiopulmonary function of anesthetized patients. Because of such concerns, many authors have recommended intraperitoneal pressures of 15 mm Hg or less before initial entry and throughout the duration of laparoscopy.<sup>4,11-14</sup>

The purpose of this study was to determine whether transient high intraperitoneal pressure (25–30 mm Hg) used just before primary trocar insertion had any detrimental effects on hemodynamic or pulmonary parameters in healthy women undergoing laparoscopic surgery.

## Materials and methods

From January 2004 through June 2004, 100 healthy women (American Society of Anesthesiologists [ASA] physical status 1 or 2), underwent operative laparoscopy consecutively at a university-affiliated hospital by the senior author (GAV). Indications for the procedure were: chronic pelvic pain (CPP,  $n = 66$ ), pelvic mass ( $n = 7$ ), CPP and pelvic mass ( $n = 4$ ), and primary or secondary infertility ( $n = 23$ ).

All patients were operated on under general endotracheal anesthesia including muscle relaxants. Anesthesia was delivered and monitored by a Datex S/5 Anesthesia Delivery Unit (Datex-Ohmeda, Helsinki, Finland).

The patients were placed in appropriate stirrups and dorsolithotomy position. Hemodynamic parameters and pulmonary compliance were recorded manually. With patients horizontal on the table, a nondisposable, 1.7-mm outside diameter Veres needle (Karl Storz, Tuttlingen, Germany) was first tested for proper function under CO<sub>2</sub> flow of 1 L/minute open to room air (pressure zero mm Hg). The needle was slowly inserted infraumbilically into the abdomen under continuous CO<sub>2</sub> flow of 1 L/minute. Insufflation pressures were recorded from an insufflator (Karl Storz) as the needle slowly traversed the various layers of the abdominal wall (i.e., fat, fascia-muscle, preperitoneal space).

The initial intraperitoneal insufflation pressure (IPIP) was recorded. When the IPIP pressure was 9 mm Hg or lower, the insufflation rate was set at maximum (>10 L/min) on the insufflator. However, the actual insufflation CO<sub>2</sub> flow never exceeded 2.5 L/minute being limited by the Veres needle parameters. If the initial pressure was greater than 9 mm Hg, the Veres needle was slowly withdrawn; and if the pressure remained above 9 mm Hg, the Veres needle was completely withdrawn and reinserted at a different site (i.e., suprapubic, off to midline, left upper quadrant).<sup>2</sup> Information on CO<sub>2</sub> volume, heart rate, blood pressure (non-invasive), oxygen saturation, and pulmonary compliance were prospectively recorded at preset pressures on the insufflator of 10-, 15-, 20-, 25-, and 30 mm Hg. Once the Veres needle was removed, a reusable, 10-mm diameter pyramidal trocar was inserted at the same site. A 10-mm, zero-degree laparoscope was introduced under direct vision on the monitor, and the abdominal contents immediately under the Veres needle and primary trocar entry sites were inspected for injuries to bowel, omentum, or vessels before the patient was tilted to Trendelenburg position. The 30 mm Hg pressure was maintained long enough to insert the primary trocar; usually less than 2 to 3 minutes. The abdomen was then immediately decompressed to the operating pressure of 15 mm Hg, and the patient was tilted to Trendelenburg position. The pulmonary compliance was recorded at maximal head-down tilt (approximately 30 degrees) and during the duration of the surgery at an operating pressure of 15 mm Hg. All secondary 5- to 10-mm trocars were inserted during the high-pressure phase under direct vision.

Differences in outcomes were evaluated using the *t* test in Microsoft Excel 2003 (Microsoft Corporation, Redmond, WA). Significance was set at  $p < .05$ .

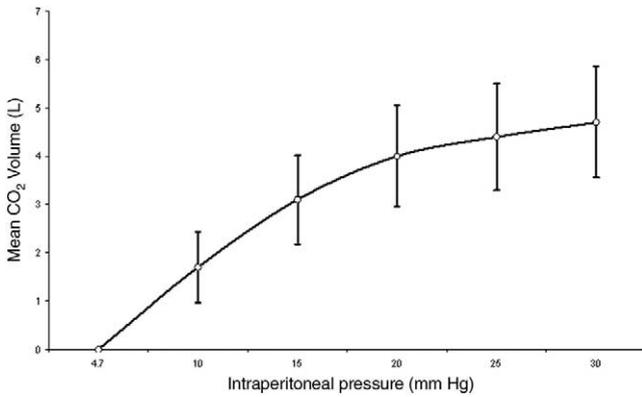
## Results

The 100 women had a mean age of 34 years (range 19–58 years), body mass index (BMI) of 25.5 kg/m<sup>2</sup> (range 17.1–39.4 kg/m<sup>2</sup>), and parity of 1.1 (range 0–5).

The mean initial IPIP was 4.7 mm Hg (range 2–9 mm Hg). The single patient with an initial entry pressure of 9 mm Hg had a BMI of 39.4 kg/m<sup>2</sup>. Figure 1 illustrates the relationship between CO<sub>2</sub> insufflation volume and intraperitoneal pressure. The mean volume of CO<sub>2</sub> at IPIP of 10-, 15-, 20-, 25-, and 30 mm Hg was 1.7, 3.1, 4, 4.4, and 4.7 L, respectively.

There was no statistically significant change in the heart rate or pulse pressure between IPIP of 15- and 30 mm Hg, and the oxygen saturation remained above 92% in all cases (Figure 2). Neither significant bradycardia or hypotension was encountered.

The difference in CO<sub>2</sub> volumes required to increase the IPIP from 15- to 30 mmHg was 1.6 L ( $p < .0001$ ). There was a statistically significant rise in the mean arterial pressure between IPIP of 15- and 30 mm Hg ( $p < .0001$ , Figure 2).



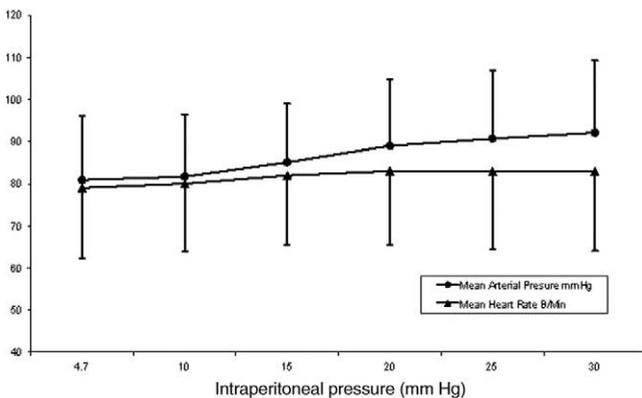
**Figure 1** Mean CO<sub>2</sub> volume (±SD) versus intraoperative pressure.

The maximum mean pulmonary compliance was recorded before the commencement of peritoneal insufflation while the patient was in a horizontal position (57.4 mL/cm H<sub>2</sub>O). Once the abdomen was insufflated, there was an inversely related decrease in pulmonary compliance as the intraoperative pressure increased. A 24% ( $p < .0001$ ) drop in pulmonary compliance was seen at an IPIP of 15 mm Hg, and a further 21% ( $p < .0001$ ) decrease was seen when the IPIP reached 30 mm Hg (Figure 3). Despite these statistically significant findings, these changes were not clinically significant.

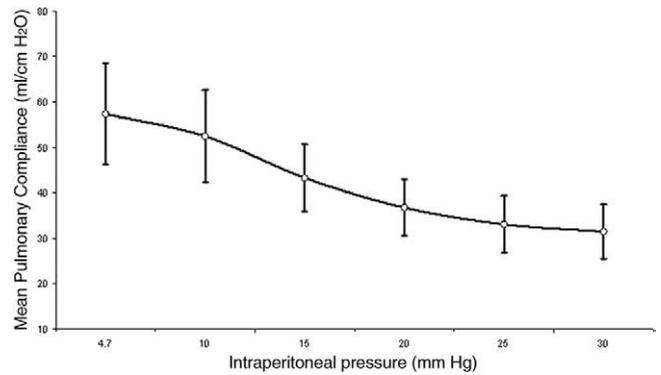
Once the IPIP was decreased to 15 mm Hg and the patient was tilted to Trendelenburg position, the pulmonary compliance remained depressed to similar values reported during 25 mm Hg-insufflation pressures in the horizontal position for the duration of surgery.

**Discussion**

Access into the abdominal cavity for minimally invasive surgery remains a major challenge. Although numerous innovative techniques and instrument modification have been explored, abdominal access complications have not



**Figure 2** Mean arterial pressure and heart rate (±SD) versus intraoperative pressure.



**Figure 3** Mean pulmonary compliance (±SD) versus intraoperative pressure.

been eliminated or even reduced. Because the frequency of serious complications is less than one per 1000, prospective clinical trials comparing the various methods are lacking. Data from limited prospective randomized comparisons and prospective and retrospective observational cohort studies and surveys do not allow recommendations of one method over the others.<sup>3-5,7</sup> The classic entry technique of Veres needle CO<sub>2</sub> followed by trocar insertion remains the most popular method of peritoneal access among gynecologists.<sup>15</sup> Using this technique, two sharp instruments, namely the Veres needle and the primary trocar, are inserted into the abdomen blindly. At times, it is difficult to differentiate puncture injuries caused from the Veres needle or the tip of the trocar.<sup>7</sup> Small punctures (less than 2 mm in diameter) can result from the tip of the trocar, while larger punctures (greater than 2 mm in diameter) have occurred by wiggling the Veres needle side to side.<sup>16</sup>

A study<sup>7</sup> reviewed the available evidence and reported that the Veres needle caused less than 20% of all laparoscopic entry injuries. Another study reported that 31 (12.6%) of 246 litigated laparoscopic entry injuries were ascribed to the Veres needle.<sup>17</sup> Therefore, the estimated incidence of hemorrhagic and visceral injury caused by the Veres needle is 0.05 and 0.17 (range 0.05-0.25) per 1000 cases, respectively.<sup>18-21</sup>

In a previous study, we stipulated that the Veres needle causes entry-related complications. However, we proposed that visceral injuries may be self-limiting and of less significance, while vascular injuries, although significant, may be less catastrophic than those caused by trocars.

In the last decade, we have been striving to make the classic entry technique safer for our patients and more user-friendly for our trainees. In a study of 259 laparoscopies, we concluded that the Veres needle can be used as an interactive guide to establish correct intraoperative placement. An initial intraoperative insufflation CO<sub>2</sub> pressure of 8 mm Hg or less (median 4, range 2-8 mm Hg) always indicated correct placement in the peritoneal space. Pressure greater than 8 mm Hg indicated interstitial placement including the preperitoneal space and colon on two occasions.

In the present study of 100 additional consecutive laparoscopies, we confirmed the previous findings with a me-

dian initial IPIP of 4 mm Hg and a range of 2 to 9 mm Hg. The single patient with an initial IPIP of 9 mm Hg had a BMI of 39 kg/m<sup>2</sup>. We have previously determined that the initial IPIP correlated positively with the weight and BMI of women.<sup>2</sup> Initial intraperitoneal CO<sub>2</sub> insufflation pressure of less than 9 mm Hg also has been reported in men and women undergoing laparoscopy.<sup>10,22,23</sup>

Therefore, the Veres needle can be used to the surgeon's advantage as an interactive guide during CO<sub>2</sub> insufflation to indicate intraperitoneal placement when the pressure is less than 9 mm Hg.

After correct placement of the Veres needle, the next step is to establish an "appropriate" pneumoperitoneum. However, what constitutes an appropriate pneumoperitoneum has not been clearly defined and remains a matter of debate. Traditionally, experts and textbooks define "appropriate pneumoperitoneum" by the insufflated volume of CO<sub>2</sub>, usually 2 to 4 L, before the primary trocar insertion. Others define it by insufflating to a pressure of 10 to 15 mm Hg.

In one prospective laparoscopy audit involving 832 patients, the pressure technique (median 14 mm Hg, range 8–22 mm Hg) for insufflation was used in 464 patients (55.8%), the volume technique in 316 (38%) and a specific technique was not stated in 52 instances (6.2%).<sup>23</sup> The average volume of CO<sub>2</sub> used in the pressure- and volume-technique groups was 4.3 L and 2.82 L, respectively (*p* > .01). The authors reported that the complication rate in the pressure-technique group was significantly lower than that found with the volume technique (4.1% vs 8.2%).<sup>23</sup> The authors recommended that the pressure technique should be the one to be preferred during laparoscopic entry.

Another study determined that 3 L and 4 L of insufflated CO<sub>2</sub> volume would establish intraperitoneal pressures of 10- and 15 mmHg, respectively.<sup>10</sup> Furthermore, the authors demonstrated that when a downward 3-kg force was applied to the umbilicus by the primary trocar, necessary to insert the primary trocar, the intraabdominal CO<sub>2</sub> bubble was reduced to zero; while when the same force was applied at 25 mm Hg pressure, at least 4-cm deep CO<sub>2</sub> gas bubble was maintained in all cases.

These observations have led some surgeons to recommend the so-called high-pressure entry technique.<sup>2,8,10</sup> This technique requires pressures of up to 25- and even 30 mm Hg during the insertion of the primary trocar and immediately decompression of the abdomen to 15 mm Hg before Trendelenburg positioning and the commencement of surgery.

In the present study, we expanded the relationship of insufflated CO<sub>2</sub> volume to intraperitoneal pressure of up to 30 mm Hg. Once again, we confirmed our previous findings and those by other researchers<sup>10</sup> on the relationship of insufflated CO<sub>2</sub> and intraabdominal pressures.

We have adapted and studied the high-pressure entry technique since 1997. We have found that our trainees find it more user-friendly and less intimidating than the volume technique practice used before 1997. Since 1997, we have

encountered no major vessel injury in over 2800 laparoscopies. We had one injury with the primary trocar to the sigmoid colon, which was subsequently found to be densely adhered to infraumbilical site. We have encountered seven bowel, one major vessel, and one combined through-and-through sigmoid colon and left common iliac vein injury during abdominal access in 3472 laparoscopies before 1997 using the volume technique.<sup>24</sup>

In another study, the high-pressure entry technique has been used since 1989. The authors reported two bowel perforations and no visceral complications in 3041 patients. In both patients, the bowel was found to be adhered to the anterior abdominal wall.<sup>8</sup>

Although the high-pressure entry technique is easier for the surgeon and safer for the patient, it has not been widely accepted for fear of compromising hemodynamic and pulmonary functions. The present study monitored noninvasively all cardiovascular parameters and pulmonary compliance during the initial entry using insufflation pressures up to 30 mm Hg. Although we found minor changes in cardiovascular parameters, none of them were clinically significant, and all of them reverted to normal values once the pressure was decreased to 15 mm Hg for the duration of the surgery. We did find a gradual decrease in pulmonary compliance from the initial insertion of the Veres needle to a pressure of 15 mm Hg and an additional 21% decrease from 15- to 30 mm Hg. We conclude that although alterations in pulmonary compliance are statistically significant, they have no clinical significance and are tolerated well by healthy women. It is of interest to note that the compliance measured at 15- and 30 mm Hg remained the same for the duration of surgery once the patient was placed in the Trendelenburg position although the intraperitoneal pressure was decreased back to 15 mm Hg. A similar observation was made by other researchers.<sup>10</sup> These authors noted that the maximum respiratory effect of 25 mm Hg intraabdominal pressure (with the patient horizontal) was not greater than the effect of Trendelenburg position with intraabdominal pressure of 15 mm Hg.

It must be emphasized, however, that all studies reporting on the high-pressure entry technique have been performed on healthy women (ASA physical status 1 or 2). It is recommended that patients with compromised cardiopulmonary functions not be exposed to such high pressures either during the initial entry to the abdomen or during the laparoscopic procedure itself. Such patients may be better served using alternative entry techniques or using lower intraperitoneal pressures.

## Conclusion

We have reaffirmed that the Veres needle can be used as an interactive guide to indicate correct intraabdominal placement when the pressure is less than 9 mm Hg. The high-pressure technique is safer for our patients and less

intimidating to our trainees. During laparoscopic entry, the transient use of hyperinsufflated pneumoperitoneum caused minor hemodynamic alterations with no clinical significance. Although alterations in pulmonary compliance were statistically significant, they had no clinical significance and were tolerated well by healthy women.

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