

Effect of body habitus and parity on insufflated CO₂ volume at various intraabdominal pressures during laparoscopic access in women

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KEYWORDS:

Laparoscopy access;
Pneumoperitoneum;
Body habitus;
Body weight;
Parity

Abstract

STUDY OBJECTIVE: To determine height, weight, body mass index (BMI), parity, and age effect on the volume of CO₂ pneumoperitoneum during laparoscopic access in women.

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

SETTING: University-affiliated teaching hospital.

PATIENTS: From January through June 2004, 100 healthy women underwent operative laparoscopic surgery consecutively by the senior author (GAV). Indications were: chronic pelvic pain (CPP, n = 66), pelvic mass (n = 7), CPP and pelvic mass (n = 4), infertility (n = 23). Median (range) height, weight, BMI, parity and age were 1.65 m (1.45–1.85 m), 70 kg (43–118 kg), 25.5 kg/m² (17–39 kg/m²), 1.1 (0–5), and 34 years (19–58 years), respectively.

INTERVENTIONS: While in supine position, patients received general endotracheal anesthesia and muscle relaxants. Pneumoperitoneum was established by reusable Veres needle. The insufflated CO₂ volume was serially recorded at intraperitoneal insufflation pressures (IPIPs) of 10, 15, 20, 25, and 30 mm Hg. The primary 10-mm trocar was introduced at IPIP of 30 mm Hg. Upon entering the peritoneal cavity, the abdominal contents were visualized with the laparoscope to ensure there was no injury, and the IPIP was immediately reduced back to the operating pressure of 15 mm Hg before switching the patient to the Trendelenburg position.

MEASUREMENTS AND MAIN RESULTS: The mean (SD) insufflated CO₂ volumes at 10, 15, 20, 25, and 30 mm Hg were 1.7 (0.74) L, 3.1 (0.9) L, 3.96 (1.05) L, 4.42 (1.1) L and 4.72 (1.14) L, respectively. Using multivariate analysis, we demonstrated that at 20 to 30 mm Hg the insufflated CO₂ volume correlated positively with the height, weight and BMI of women. Parity correlated positively at all pressures. There was no correlation with age at any pressure.

CONCLUSIONS: Higher CO₂ volume is required to establish appropriate pneumoperitoneum in tall, overweight, and parous women at 20 to 30 mm Hg. Setting the IPIP at 20 to 30 mm Hg before primary trocar insertion eliminates the need to monitor CO₂ insufflated volume regardless of women's age, parity, and body habitus.

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Laparoscopy has become an integral part of gynecologic practice as a diagnostic tool as well as for operative procedures. Laparoscopy also has been shown to be safer and more beneficial than laparotomy,^{1,2} and provides significant benefits compared with laparotomy for patients, providers, and surgeons.³

Among gynecologists, injuries to bowel and major blood vessels during laparoscopic access occur at a frequency ranging from 0.05% to 0.14%.^{4–8} This frequency has remained the same during the last 25 years,⁸ and all methods of laparoscopic entry are associated with a similar rate of major complications.^{4–13}

The most crucial step of laparoscopic entry, regardless of the method used, is the introduction of the primary trocar/cannula. The most serious complications occur during this step.^{8,14–19} Since all entry techniques are associated with a similar frequency of entry complications, most gynecologists world-wide practice the “classic” or closed-entry technique of Veres-pneumoperitoneum-trocar entry.^{5,8,10,11,13,20,21} It has been shown that an initial Veres intraperitoneal pressure (VIP-pressure) of 10 mm Hg or less^{5,22–26} is the most reliable indicator of correct Veres needle placement compared with other traditional safety tests or checks.²⁶ It has also been reported that the VIP-pressure, always 10 mm Hg or less, correlates positively with the woman’s weight and body mass index (BMI) and negatively with parity.²⁷

Following correct placement of the Veres needle, what constitutes an “appropriate” or “adequate” pneumoperitoneum required before the primary trocar insertion remains controversial. There are two schools of thought: one defines appropriate pneumoperitoneum by an arbitrary volume of 1 to 4 L and the other by an arbitrary pressure of 10 to 15 mm Hg.^{22,28} In one study, the average CO₂ volume used in the pressure-technique group (median pressure 14 mm Hg) was greater than that used in the volume-technique group (4.3 vs 2.8 L; $p > .01$), and the complication rate in the pressure-technique group was lower than that found with the volume technique (4.1% vs 8.2%, $\chi^2 = 5.2$, $0.5 > p > .02$).²² Before primary trocar insertion, intraabdominal CO₂ insufflation pressure up to 10 mm Hg,²⁹ 15 mm Hg,^{9,23,30} 14 to 18 mm Hg,¹² 20 mm Hg,^{26,31} and even 25 to 30 mm Hg^{25,28,32–35} has been advocated. It has been shown that high intraabdominal pressure splints the anterior abdominal wall resulting in safer laparoscopic entry.^{5,28,32,35} It also has been shown that the transient use of high-pressure pneumoperitoneum (< 2 minutes) causes minor hemodynamic changes with no clinical significance, while the respiratory effects were not different than the effects of Trendelenburg position with intraabdominal pressure at 15 mm Hg.^{28,35}

Because the high intraperitoneal pressure (HIP-pressure) is gaining acceptance, in the present study, we evaluated the effect, if any, of height, weight, BMI, parity, and age on the volume of CO₂ pneumoperitoneum from 10 to 30 mm Hg pressure during laparoscopic access in women.

Table 1 Median and range of patient characteristics (n = 365)

Variable	Median	Range
Age (years)	34	18–87
Height (m)	1.64	1.45–1.85
Weight (kg)	65	40–120
BMI (kg/m ²)	24.3	16.3–46.9
Parity	1	0–5

Materials and methods

This was a prospective, observational cohort study. From January through June 2004, 100 healthy women underwent operative laparoscopic surgery consecutively by the senior author (G.A.V.). Indications for surgery were: chronic pelvic pain (CPP, n = 66), pelvic mass (n = 7), CPP and pelvic mass (n = 4), and infertility (n = 23).

The medians and ranges of patient characteristics are shown in Table 1.

All patients were operated on under general endotracheal anesthesia including muscle relaxants, in appropriate stirrups and dorsolithotomy position. With patients horizontal, a nondisposable Veres needle (1.7-mm outside diameter, Karl Storz, Tuttlingen, Germany) was tested for proper function under CO₂ flow of 1 L/minute open to room air (pressure zero mm Hg). The Veres was then inserted into the abdomen infraumbilically or at the left upper quadrant under continuous flow of at least 1 L/minute and a preset pressure of 10 mm Hg. The anatomy under the umbilicus was palpated, and in thin patients, the umbilicus was elevated, pulled caudally and stabilized by hand while the needle was inserted. In obese women, the Veres needle was inserted at between a 45° to 90° angle to the horizontal plane.

An initial intraperitoneal pressure of 10 mm Hg or less was used as an indicator of correct intraperitoneal Veres needle placement. We did not use any of the so-called Veres needle safety tests.

The pressure on the insufflator (Karl Storz, Tuttlingen, Germany) was set incrementally at 10, 15, 20, 25, and 30 mm Hg, and the corresponding volumes of insufflated CO₂ were recorded. Although the insufflation rate was set at maximum of 30 L/minute on the insufflator, the CO₂ flow rate through the Veres needle never exceeded 2.5 L/minutes. At the final pressure of 30 mm Hg, a 10-mm diameter primary pyramidal trocar/cannula was inserted at the same site following roughly the same direction and angle of the Veres needle.²⁵ In 50 randomly allocated women, entry was achieved using the EndoTIP trocar-less cannula (Karl Storz, Tuttlingen, Germany) under direct vision.³⁶

The intraperitoneal pressure was reduced to the standard operating pressure of 15 mm Hg immediately after visual confirmation of safe entry before switching the patient to Trendelenburg position.³⁵

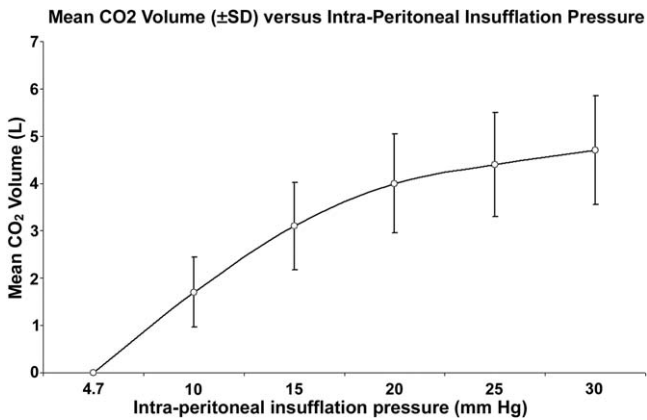


Figure 1 Mean CO₂ volume (±SD) versus intraperitoneal insufflation pressure.

Results were analyzed using descriptive statistics and multivariate regression using the SAS software package (SAS Institute, Cary, NC). A p-value of <0.05 was considered statistically significant.

Results

The mean (± SD) and 95% CI of insufflated CO₂ volume at 10, 15, 20, 25, and 30 mm Hg were 1.7 ± 0.74 L (95% CI 1.56–1.86), 3.1 ± 0.9 L (95% CI 2.9–3.27), 3.96 ± 1.05 L (95% CI 3.75–4.12), 4.42 ± 1.1 L (95% CI 4.2–4.6), and 4.72 ± 1.14 L (95% CI 4.49–4.95), respectively, and their relationship is shown in Figure 1. At 15 mm Hg, there was no statistically significant correlation between the insuff-

lated CO₂ volume (pneumoperitoneum) and the women’s height (r = .189, p = .059), weight (r = .120, p = .234), BMI (r = .058, p = .564), and age (r = .073, p = .473) (Figure 2).

At 20 mm Hg, the insufflated CO₂ volume correlated positively with the women’s height (r = .280, p = .005), weight (r = .301, p = .002), BMI (r = .253), p = .011), and parity (r = 0.280, p = .005) (Figure 3).

At 25 mm Hg, the insufflated CO₂ volume correlated positively with the women’s height (r = .281, p = .005), weight (r = .366, p < .001), BMI (r = .306, p = .002), and parity (r = .389, p < .001) (Figure 4).

At 30 mm Hg, the final CO₂ volume correlated positively with the women’s height (r = .289, p = .004), weight (r = .378, p < .001), BMI (r = .318, p = .001), and parity (r = .297, p = .003) (Figure 5).

There was no correlation between the insufflated CO₂ and the age of women at pressure of 10 to 30 mm Hg.

Discussion

Injuries to viscera and retroperitoneal vessels continue to be major complications of the primary trocar/cannula insertion.^{12,37–41} In general, trocar injuries to bowel occur under the following conditions: (1) The bowel is adhered to the abdominal wall at the insertion site (Type 2 lesion)^{3,5}; (2) The bowel is overdistended by contents (Type 1 lesion)^{3,5}; and (3) The bowel is pushed by the sharp tip and trapped posteriorly against intraabdominal contents or the abdominal wall (Type 1 lesion). Retroperitoneal vessel injury oc-

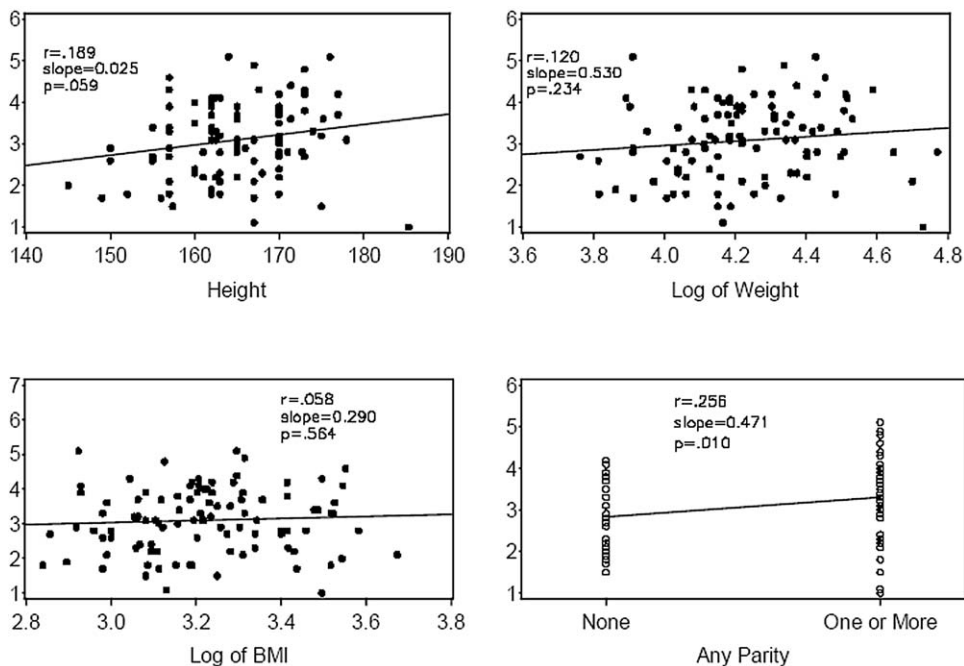


Figure 2 Scattergrams and correlation coefficients of insufflated CO₂ volume and women’s height, weight, body mass index (BMI), and parity at intraperitoneal insufflation pressure of 15 mm Hg.

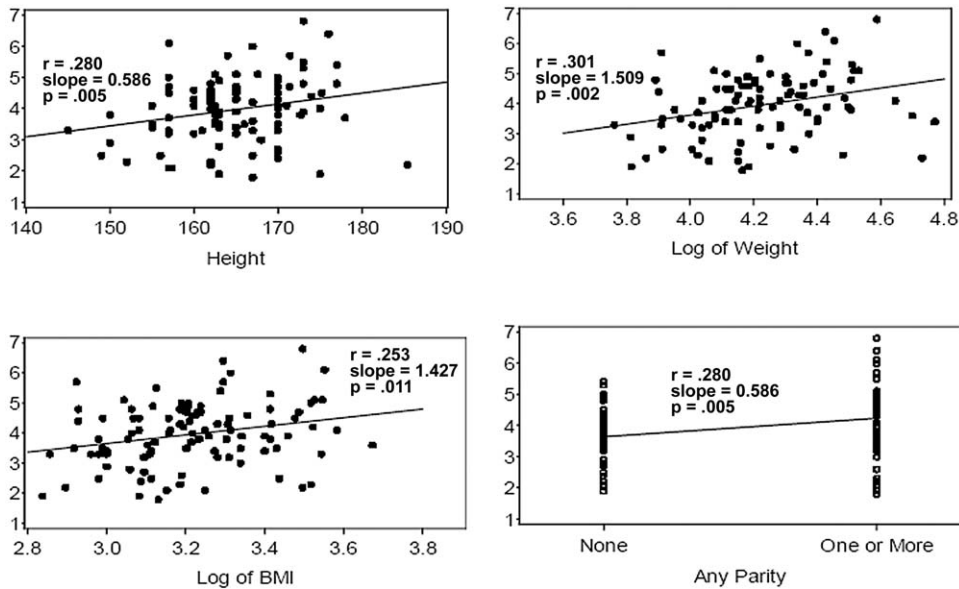


Figure 3 Scattergrams and correlation coefficients of insuflated CO₂ volume and women's height, weight, body mass index (BMI), and parity at intraperitoneal insufflation pressure of 20 mm Hg.

curs when the tip of the trocar penetrates too far inside the abdominal cavity (Type 1 lesion).

When the bowel is adhered at the umbilical entry site, injury has been encountered by all methods of entry. When the bowel is known or suspected to be adhered at the entry site, injury may be avoided by entry through the left upper quadrant.^{31,34,42} To avoid Type 1 injuries, defined as injuries to normally situated structures,^{3,5} we have been practicing the HIP pressure (HIP-entry 25 to 30 mm Hg) since 1997. During this time, we have encountered only one injury with the primary trocar insertion. This injury was to the transverse colon,

which was adherent to the anterior abdominal wall. No vascular injury was noted in more than 2500 laparoscopies.

The high-pressure entry philosophy was introduced in 1989.³³ The authors stated that at 15 mm Hg, the surgeon can almost always palpate aortic bifurcation, while at 30 mm Hg, it is not usually possible to palpate the aorta. The theory behind the use of higher pressures (25 to 30 mm Hg) is that high pressure splints the anterior abdominal wall against the indenting force of the trocar/cannula system, thus minimizing the chances of the sharp trocar tip reaching the normally situated intraabdominal struc-

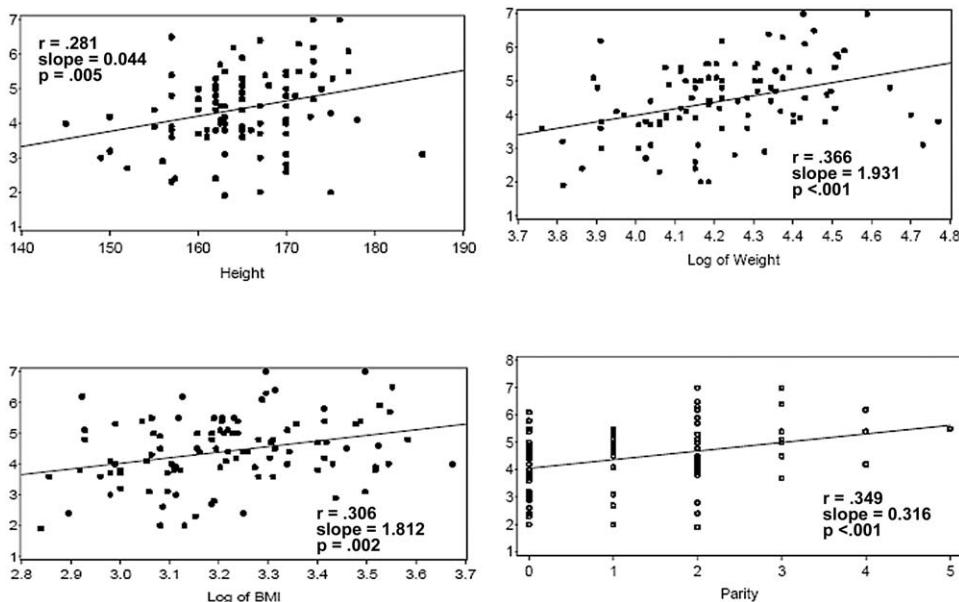


Figure 4 Scattergrams and correlation coefficients of insuflated CO₂ volume and women's height, weight, body mass index (BMI), and parity at intraperitoneal insufflation pressure of 25 mm Hg.

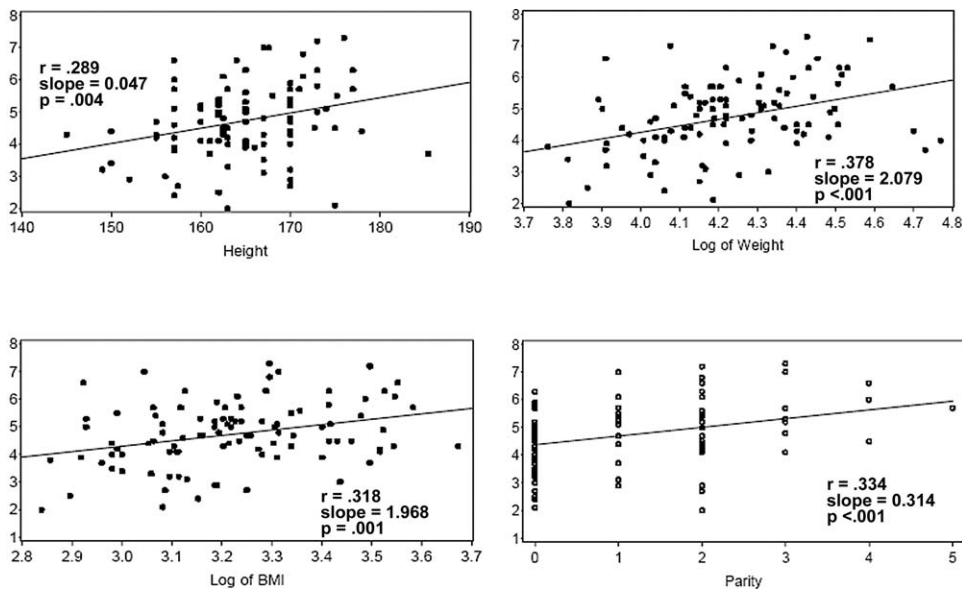


Figure 5 Scattergrams and correlation coefficients of insuflated CO₂ volume and women's height, weight, body mass index (BMI), and parity at intraperitoneal insufflation pressure of 30 mm Hg.

tures and creates a larger gas bubble as an additional safety feature. In 3041 laparoscopic entries under high pressure, the authors encountered no vascular injuries and two bowel injuries in bowel directly adhered to the undersurface of the umbilicus.³³

The combined experience from these three case series, involving 8997 laparoscopic entries using pressure of 25 to 30 mm Hg, reported four (0.04%) bowel injuries^{5,33,35} and one (0.01%) major vessel injury.⁵ In all cases of bowel injury, the bowel was adhered to the entry site; while in the case of the vascular injury, there was inadvertent loss of pneumoperitoneum during insertion of the primary trocar.⁵

One study calculated the abdominal volume during creation of pneumoperitoneum in six female pigs.⁴³ It reported a linear increase in the calculated abdominal volume as the pneumoperitoneum pressure increased from zero to 15 mm Hg. However, there was minimal increase in the actual abdominal volume as the pneumoperitoneum pressure was increased from 15 to 30 mm Hg, and 94% of the abdominal volume was achieved at 15 mm Hg. The authors concluded that changes in the abdominal volume did not favor 30 mm Hg pressure over the more commonly used 15 mm Hg before primary trocar insertion.⁴³

It must be emphasized that the rationale for increasing the intraabdominal pressure from 15 to 30 mm Hg is not to increase the abdominal volume, but to increase the abdominal wall tension. By applying the well-known physical law of Laplace (pressure = wall tension/radius) for a cylindrical structure, such as the abdomen, the abdominal wall tension doubles as the intraabdominal pressure increases from 15 to 30 mm Hg for a fixed volume. Indeed, one study demonstrated in women undergoing laparoscopy that when a 3-kg force was applied to an umbilical trocar, the intraabdominal CO₂ bubble reduced to zero at 15 mm Hg, and the tip of the trocar touched abdominal contents. When the same force

was applied at 25 mm Hg pressure, a CO₂ gas bubble of at least 4 cm deep was maintained in all cases, and the tip of the trocar never touched intraabdominal contents.²⁸

It has been reported that the use of transient high pneumoperitoneum (<2 min) does not adversely affect cardiopulmonary function in healthy women.^{25,28} The use of the high pressure–entry technique has been slowly gaining acceptance, such that the initial recommendation of 10 mm Hg pneumoperitoneum has been increased to 30 mm Hg before primary trocar insertion.

In the present study, we found that the women's body habitus and parity correlated positively with intraabdominal pressure from 20 to 30 mm Hg. In another study, no significant relationship was found between the delivered volume of CO₂ insuflated at zero to 30 mm Hg pressures and the height, weight, and BMI of 41 men undergoing laparoscopic urologic procedures.⁴³

We have noted increased acceptance of the use of the HIP-entry technique in our trainees and other gynecologists once they become familiar with the technique and its safety. In a Canadian survey of obstetricians and gynecologists (51% respondents), trocar injuries appeared to occur twice as often among those who experienced difficulty with trocar insertion ($p = .04$). When difficulty was associated with the primary trocar, the correlation with injury was even more striking ($p = .002$). When difficulty with trocar insertion was correlated with the sex of the surgeon, it was noted that a higher proportion of women experienced difficulty inserting both the primary and secondary trocar.²⁰

Conclusion

The present study indicated that higher CO₂ volume is required to establish appropriate pneumoperitoneum in tall,

overweight, and parous women at intraabdominal pressures of 20 to 30 mm Hg. We propose that setting the intraperitoneal pressure at 20 to 30 mm Hg before the primary trocar insertion eliminates the need to monitor CO₂ insufflated volume regardless of women's age, parity, and body habitus.²¹

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