

SOGC CLINICAL PRACTICE GUIDELINE

No. 193, May 2007

Laparoscopic Entry: A Review of Techniques, Technologies, and Complications

This guideline has been reviewed and approved by the Executive and Council of the Society of Obstetricians and Gynaecologists of Canada.

PRINCIPAL AUTHORS

George A. Vilos, MD, FRCSC

Artin Ternamian, MD, FRCSC

Jeffrey Dempster, MD, FRCSC

Philippe Y. Laberge, MD, FRCSC

CLINICAL PRACTICE GYNAECOLOGY COMMITTEE

George Vilos, MD, FRCSC (Chair), London ON

Guylaine Lefebvre, MD, FRCSC (Past Chair), Toronto ON

Catherine Allaire, MD, FRCSC, Vancouver BC

Jagmit Arneja, MD, FRCSC, Winnipeg MB

Colin Birch, MD, FRCSC, Calgary AB

Tina Dempsey, MD, Wolfeboro NH

Jeffrey Dempster, MD, FRCSC, Halifax NS

Philippe Yves Laberge, MD, FRCSC, Ste-Foy QC

Dean Leduc, MD, Orleans ON

Valerie Turnbull, RN, Winnipeg MB

Frank Potestio, MD, FRCSC, Thunder Bay ON

Evidence: English-language articles from Medline, PubMed, and the Cochrane Database published before the end of September 2005 were searched, using the key words laparoscopic entry, laparoscopy access, pneumoperitoneum, Veress needle, open (Hasson), direct trocar, visual entry, shielded trocars, radially expanded trocars, and laparoscopic complications.

Values: The quality of evidence was rated using the criteria described in the Report of the Canadian Task Force on the Periodic Health Examination.

Recommendations and Summary Statement

1. Left upper quadrant (LUQ, Palmer's) laparoscopic entry should be considered in patients with suspected or known periumbilical adhesions or history or presence of umbilical hernia, or after three failed insufflation attempts at the umbilicus. (II-2 A) Other sites of insertion, such as transuterine Veress CO₂ insufflation, may be considered if the umbilical and LUQ insertions have failed or have been considered and are not an option. (I-A)
2. The various Veress needle safety tests or checks provide very little useful information on the placement of the Veress needle. It is therefore not necessary to perform various safety checks on inserting the Veress needle; however, wagging of the Veress needle from side to side must be avoided, as this can enlarge a 1.6 mm puncture injury to an injury of up to 1 cm in viscera or blood vessels. (II-1 A)
3. The Veress intraperitoneal (VIP-pressure ≤ 10 mm Hg) is a reliable indicator of correct intraperitoneal placement of the Veress needle; therefore, it is appropriate to attach the CO₂ source to the Veress needle on entry. (II-1 A)
4. Elevation of the anterior abdominal wall at the time of Veress or primary trocar insertion is not routinely recommended, as it does not avoid visceral or vessel injury. (II-2 B)
5. The angle of the Veress needle insertion should vary according to the BMI of the patient, from 45° in non-obese women to 90° in obese women. (II-2 B)
6. The volume of CO₂ inserted with the Veress needle should depend on the intra-abdominal pressure. Adequate pneumoperitoneum should be determined by a pressure of 20 to 30 mm Hg and not by predetermined CO₂ volume. (II-1 A)
7. In the Veress needle method of entry, the abdominal pressure may be increased immediately prior to insertion of the first trocar. The high intraperitoneal (HIP-pressure) laparoscopic entry technique does not adversely affect cardiopulmonary function in healthy women. (II-1 A)
8. The open entry technique may be utilized as an alternative to the Veress needle technique, although the majority of gynaecologists

Abstract

Objective: To provide clinical direction, based on the best evidence available, on laparoscopic entry techniques and technologies and their associated complications.

Options: The laparoscopic entry techniques and technologies reviewed in formulating this guideline include the classic pneumoperitoneum (Veress/trocar), the open (Hasson), the direct trocar insertion, the use of disposable shielded trocars, radially expanding trocars, and visual entry systems.

Outcomes: Implementation of this guideline should optimize the decision-making process in choosing a particular technique to enter the abdomen during laparoscopy.

Key Words: Laparoscopy, entry, pneumoperitoneum, Veress needle, Hasson technique, visual entry system

This guideline reflects emerging clinical and scientific advances as of the date issued and is subject to change. The information should not be construed as dictating an exclusive course of treatment or procedure to be followed. Local institutions can dictate amendments to these opinions. They should be well documented if modified at the local level. None of these contents may be reproduced in any form without prior written permission of the SOGC.

prefer the Veress entry. There is no evidence that the open entry technique is superior to or inferior to the other entry techniques currently available. (II-2 C)

9. Direct insertion of the trocar without prior pneumoperitoneum may be considered as a safe alternative to Veress needle technique. (II-2)
10. Direct insertion of the trocar is associated with less insufflation-related complications such as gas embolism, and it is a faster technique than the Veress needle technique. (I)
11. Shielded trocars may be used in an effort to decrease entry injuries. There is no evidence that they result in fewer visceral and vascular injuries during laparoscopic access. (II-B)
12. Radially expanding trocars are not recommended as being superior to the traditional trocars. They do have blunt tips that may provide some protection from injuries, but the force required for entry is significantly greater than with disposable trocars. (I-A)
13. The visual entry cannula system may represent an advantage over traditional trocars, as it allows a clear optical entry, but this advantage has not been fully explored. The visual entry cannula trocars have the advantage of minimizing the size of the entry wound and reducing the force necessary for insertion. Visual entry trocars are non-superior to other trocars since they do not avoid visceral and vascular injury. (2 B)

J Obstet Gynaecol Can 2007;29(5):433–447

INTRODUCTION

Laparoscopy (Gr: *Laparo*-abdomen, *scopein*-to examine) is the art of examining the abdominal cavity and its contents. It requires insertion of a cannula through the abdominal wall, distention of the abdominal cavity with gas or air (pneumoperitoneum), and visualization and examination of the abdomen's contents with an illuminated telescope. With the advent of videocameras and other ancillary instruments, laparoscopy rapidly advanced from a being a diagnostic procedure to one used in fallopian tubal occlusion for sterilization and eventually in the performance of numerous surgical procedures in all surgical disciplines for a variety of indications.

A minimally invasive procedure has many advantages for patients, health care systems, and society at large. A meta-analysis of 27 randomized controlled trials (RCTs) compared laparoscopy and laparotomy for benign gynaecological procedures.¹ The authors concluded that the risk of minor complications after gynaecological surgery is 40% lower with laparoscopy than with laparotomy, although the risks of major complications are similar. The overall risk for any complication is 8.9% with laparoscopy, compared with 15.2% with laparotomy (relative risk [RR] 0.6; 95% confidence interval [CI] 0.5–0.7). There is no difference between laparoscopy and laparotomy in the risk of major complications (1.4% in each group, RR 1.0; 95% CI 0.6–1.7), but minor complications were significantly less frequent with laparoscopy (7.5% vs. 13.8%, RR 0.6; 95% CI 0.5–0.7).¹

A Cochrane review of trials involving 324 patients concluded that laparoscopic surgery for benign ovarian tumours is associated with reduced risk of any adverse

effect of surgery, reduced pain, and fewer days in hospital compared with laparotomy. There was no difference between the procedures with regard postoperative infections and tumour recurrence.²

Access into the abdomen is the one challenge of laparoscopy that is particular to the insertion of surgical instruments through small incisions. Access is therefore associated with injuries to the gastrointestinal tract and major blood vessels, and at least 50% of these major complications occur prior to commencement of the intended surgery.^{3–8} This complication rate has remained the same during the last 25 years.⁸ The majority of injuries are due to the insertion of the primary umbilical trocar.⁹ Increased morbidity and mortality result when laparoscopists or patients do not recognize injuries early or do not address them quickly.⁹

To minimize entry-related injuries, several techniques, instruments, and approaches have been introduced during the last century. These include the Veress-pneumoperitoneum-trocar, “classic” or closed entry,¹⁰ the open (Hasson) technique,¹¹ direct trocar insertion without prior pneumoperitoneum,¹² use of shielded disposable trocars,^{13–15} optical Veress needle,^{16,17} optical trocars,^{18,19} radially expanding trocars,^{20,21} and a trocarless reusable, visual access cannula.^{22,23} Each of these methods of entry enjoys a certain degree of popularity according to the surgeon's training, experience, and bias, and according to regional and interdisciplinary variability.

This guideline examines the available evidence on each of the existing laparoscopic entry techniques and provides recommendations according to the Canadian Task Force on the Periodic Preventive Health Examination Care (Table 1).²⁴

CLOSED ENTRY (CLASSIC) LAPAROSCOPY

Historical

The classic, or closed entry, laparoscopic technique requires cutting of the abdominal skin with a scalpel, insufflation of air or gas into the abdomen (establishment of pneumoperitoneum), and insertion of a sharp trocar/cannula system into the abdomen. Following removal of the sharp trocar, the abdominal cavity is examined by an illuminated telescope through the cannula.

The first laparoscopy in a human was performed by Jacobeus of Sweden in 1910.²⁵ In Canada, laparoscopy was introduced by Dr Victor Gomel, University of British Columbia, Dr Jacques Rioux, Laval University, Quebec, and Dr Albert Yuzpe, University of Western Ontario, in 1970.²⁶

Key to evidence statements and grading of recommendations, using the ranking of the Canadian Task Force on Preventive Health Care

Quality of Evidence Assessment*	Classification of Recommendations†
I: Evidence obtained from at least one properly randomized controlled trial	A. There is good evidence to recommend the clinical preventive action
II-1: Evidence from well-designed controlled trials without randomization	B. There is fair evidence to recommend the clinical preventive action
II-2: Evidence from well-designed cohort (prospective or retrospective) or case-control studies, preferably from more than one centre or research group	C. The existing evidence is conflicting and does not allow to make a recommendation for or against use of the clinical preventive action; however, other factors may influence decision-making
II-3: Evidence obtained from comparisons between times or places with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of treatment with penicillin in the 1940s) could also be included in this category	D. There is fair evidence to recommend against the clinical preventive action
III: Opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees	E. There is good evidence to recommend against the clinical preventive action
	I. There is insufficient evidence (in quantity or quality) to make a recommendation; however, other factors may influence decision-making

*The quality of evidence reported in these guidelines has been adapted from the Evaluation of Evidence criteria described in the Canadian Task Force on Preventive Health Care.²⁴

†Recommendations included in these guidelines have been adapted from the Classification of Recommendations criteria described in the Canadian Task Force on Preventive Health Care.²⁴

ESTABLISHMENT OF PNEUMOPERITONEUM: THE VERESS NEEDLE

In 1947, Raoul Palmer of France popularized the use of the Veress needle using CO₂ to induce pneumoperitoneum for laparoscopy, and he subsequently published on its safety in the first 250 patients.¹⁰ Palmer emphasized that the creation of pneumoperitoneum remains a vital first step, and it is one still associated with recognized complications.

Several surveys indicate that most gynaecologists practising laparoscopy worldwide use the Veress needle-pneumoperitoneum-primary trocar technique to access the abdomen.^{8,27–33} In a Canadian survey of 407 (51% responding) obstetricians and gynaecologists, 96.3% reported always inducing pneumoperitoneum prior to insertion of the primary trocar, 1.2% sometimes, and 2% never (0.5% made no response).²⁷ Furthermore, 26.4% of respondents had experienced vessel or organ injury attributable to the Veress needle, and 25.6% and 15.0% experienced vessel or organ injury from the primary and secondary trocars, respectively.²⁷

Veress Needle Insertion Sites

Under usual circumstances, the Veress needle is inserted in the umbilical area, in the midsagittal plane, with or without stabilizing or lifting the anterior abdominal wall. In patients known or suspected to have periumbilical adhesions, or after failure to establish pneumoperitoneum after three

attempts, alternative sites for Veress needle insertion may be sought.^{34–37}

Left upper quadrant (LUQ, Palmer's point) CO₂ insufflation

In patients with previous laparotomy, Palmer advocated insertion of the Veress needle 3 cm below the left subcostal border in the midclavicular line.¹⁰ This technique should be considered in the obese as well as the very thin patient. In very thin patients, especially those with a prominent sacral promontory and android pelvis, the great vessels lie 1 cm to 2 cm underneath the umbilicus,^{38,39} and in obese women, the umbilicus is shifted caudally to the aortic bifurcation.⁴⁰

LUQ insufflation requires emptying of the stomach by nasogastric suction and introduction of the Veress needle perpendicularly to the skin. Patients with previous splenic or gastric surgery, significant hepatosplenomegaly, portal hypertension, or gastropancreatic masses should be excluded.⁴¹ There is significantly more subcutaneous fat at the umbilical area than at the LUQ insertion site. Tulikangas et al. found a positive correlation between body mass index (BMI) and the distance between various intra-abdominal organs and the insertion site.⁴¹ After establishment of the pneumoperitoneum, trocars of various diameters and shapes may be introduced at the same site as the Veress, followed by additional trocar/cannula systems inserted under direct vision, as required.^{42–50}

Transuterine Veress CO₂ insufflation

Using a long Veress needle, pneumoperitoneum has been established through the fundus of the uterus transvaginally.^{51–56} This technique has been especially helpful in obese women.^{53,55,56} In one study of 138 women weighing 250 lbs to 400 lbs, failure to establish pneumoperitoneum occurred in 13.8% (5/36) through the umbilicus, in 3.6% (3/83) through the uterus, in 8.3% (1/12) subcostally, and in 28.6% (2/7) through the open (Hasson) technique.⁵⁵ A prospective randomized study compared the conventional infraumbilical route with a transuterine route in 100 overweight and obese women (BMI ≥ 25 kg/m²) in establishing pneumoperitoneum.⁵⁶ In the infraumbilical group, pneumoperitoneum was achieved at a ratio (punctures/pneumoperitoneum) of 56/49 (1.14) with one failure, but in the transuterine group the ratio was 53/51 (1.04).⁵⁶

Trans cul-de-sac CO₂ insufflation

The posterior vaginal fornix has been reported as another site through which to establish pneumoperitoneum,⁵⁷ especially in obese women.⁵⁸

Ninth or tenth intercostal space CO₂ insufflation

Since the parietal peritoneum is adhered to the under-surface of the ribs at the costal margin, some gynaecologists insert the Veress needle through the ninth or tenth intercostal space.^{48,50,59} The inclusion and exclusion criteria are the same as per LUQ insertion. The Veress needle is inserted directly through the intercostal space at the anterior axillary line along the superior surface of the lower rib to avoid injury to the underlying neurovascular bundle.

Following pneumoperitoneum, established at 20 to 25 mm Hg pressure, 5 mm laparoscopes are introduced at Palmer's point for inspection, followed by additional trocars, inserted under direct vision, to facilitate the required surgery and/or perform adhesiolysis when indicated.

A retrospective review of 918 insufflations through the ninth intercostal space found one entry into the stomach and one into the pleural space (causing a pneumothorax) by the Veress needle.⁵⁰

Challenges

Anterior abdominal wall adhesions

Adhesions at the umbilical area are found in approximately 10% of all laparoscopies.⁴⁷ One series of 4532 laparoscopies reported an incidence of only 0.2 per 1000.⁶⁰ In women with no previous abdominal surgery, umbilical adhesions are found in 0% to 0.68% of laparoscopies. Rates of umbilical adhesions range from 0% to 15% in women with prior laparoscopic surgery, from 20% to 28% in those who have had previous laparotomy with horizontal suprapubic

incision, and from 50% to 60% in those who have had previous laparotomy with longitudinal incision.^{47,50,61,62} Patients with midline incisions performed for gynaecologic indications had significantly more adhesions (109/259, 42%) than those with all types of incisions performed for obstetric indications (12/55, 22%).⁶²

In some research protocols, preoperative ultrasonography to detect anterior wall adhesions has been found to be useful, but it needs further evaluation, and there is insufficient evidence to recommend routine preoperative ultrasound.^{63,64} In 58 of 69 subjects, laparoscopic or laparotomy findings confirmed the ultrasound findings of "restricted visceral slide" in the presence of visceral adhesions.⁶³

Angle of Veress needle insertion

Hurd et al. reported on computerized axial tomography (CT) scans of 38 unanaesthetized women of reproductive age. The position of the umbilicus was found, on average, 0.4 cm, 2.4 cm, and 2.9 cm caudally to the aortic bifurcation in normal weight (BMI < 25 kg/m²), overweight (BMI 25–30 kg/m²), and obese (BMI > 30 kg/m²) women, respectively. In all cases, the umbilicus was cephalad to where the left common iliac vein crossed the midline at the sacral promontory.³⁸ Therefore, the angle of the Veress needle insertion should vary accordingly from 45° in non-obese women to 90° in very obese women.⁴⁰

Veress needle safety tests or checks

Several studies have described tests and techniques for determining the correct placement of the Veress needle. These include the double click sound of the Veress needle, the aspiration test, the hanging drop of saline test,⁶⁵ the "hiss" sound test,⁶⁶ and the syringe test.^{34,37,67,68} Although all these tests and techniques may be helpful in accessing the peritoneal cavity, the fact that visceral and vascular injuries occur shows that they are not foolproof. In fact, a recent prospective study reported that the double click, aspiration, and hanging drop tests provided very little useful information on the placement of the Veress needle.⁶⁹ In view of recent evidence, failure to perform these tests should no longer be considered as substandard care or negligence.⁶⁹

Some surgeons waggle the Veress needle from side to side, believing that this shakes an attached organ from the tip of the needle and confirms correct intra-abdominal placement. However, this manoeuvre can enlarge a 1.6 mm puncture injury to an injury of up to 1 cm in viscera or blood vessels.⁷⁰

Elevation of the anterior abdominal wall

Many surgeons advocate elevating the lower anterior abdominal wall by hand or using towel clips at the time of Veress or primary trocar insertion.^{14,71} One study used a suprapubic port to compare the efficacy of manual

elevation below the umbilicus and of towel clips placed within and 2 cm from the umbilicus.⁷¹ They reported that only towel clips provided significant elevation of peritoneum (mean 6.8 cm above the viscera) that was maintained during the force of the primary trocar insertion.⁷¹ Using this technique, however, one surgeon caused aortic injury to two patients in one month.⁷²

Hill and Maher reported 26 (4.8%) omental perforations as the omentum was elevated (lifted by hand), together with the anterior wall, during 542 direct trocar insertions for laparoscopic access.⁷³

Number of Veress needle insertions attempts

Studies have reported placing the Veress needle into the peritoneal cavity on the first attempt at frequencies of 85.5% to 86.9%^{69,74}; two attempts were required in 8.5% to 11.6% of procedures, three attempts in 2.6% to 3.0%, and more than three attempts in 0.3% to 1.6%.^{69,74}

Complication rates were as follows: at one attempt, 0.8% to 16.3%; at two attempts, 16.31% to 37.5%; at three attempts, 44.4% to 64%; and at more than three attempts, 84.6% to 100%. Complications were extraperitoneal insufflation, omental and bowel injuries, and failed laparoscopy.^{69,74}

Extraperitoneal insufflation

Extraperitoneal insufflation is one of the most common complications of laparoscopy, frequently leading to abandonment of the procedure because further attempts to achieve pneumoperitoneum are usually unsuccessful.^{12,75,76} In one study, preperitoneal insufflation occurred in 2.7%, 15%, 44.4%, and 100% of cases at one, two, three, and more than three attempts, respectively.⁶⁹

Kabukoba and Skillern described a technique to deal with extraperitoneal insufflation that requires the laparoscope to be left in the preperitoneal space and the gas not evacuated. The Veress needle is then reintroduced into the preperitoneal space in front of the telescope and visually guided into the peritoneal cavity.⁷⁷

Veress Needle Modifications

Pressure-sensor-equipped Veress needle

A modified pressure-sensor-equipped Veress needle to provide the surgeon immediate feedback the moment the tip enters the peritoneal cavity has been described.⁷⁸

Optical Veress needle (minilaparoscopy)

The Veress needle has been modified to a 2.1 mm diameter and cannula 10.5 cm long to allow insertion of a thin (≤ 1.2 mm diameter), zero degree, semirigid fiberoptic minilaparoscope. This system may be inserted in the umbilicus or the left upper quadrant, and subsequent ancillary ports are inserted under direct vision.^{16,17}

During insertion of the assembled unit (Veress cannula and telescope) the surgeon observes a cascade of monitor colour sequences that represent different abdominal wall layers: subcutaneous fat appears yellow, fascia white, anterior rectus muscle red, and peritoneum translucent or shiny bright.^{79,80} When the Veress needle enters the peritoneum, CO₂ gas can be seen bubbling forwards, and the intra-abdominal structures soon come into view. Alternatively, some surgeons insert the optical Veress needle first, secure insufflation, and then introduce the minilaparoscope.^{17,47,49}

In patients with longitudinal abdominal wall incisions, utilization of the optical Veress system through the LUQ and insertion of the ancillary ports under direct vision may present a safer alternative. However, in a prospective study of 184 cases, two bowel perforations occurred.⁸¹ Therefore, the relative predictive risks of the optical Veress needle remain uncertain in the absence of randomized studies.^{47,82}

Veress intraperitoneal pressure (VIP pressure)

Several investigators have reported initial intraperitoneal insufflation pressures ≤ 10 mm Hg indicating correct Veress needle placement.^{69,74,83–87} Prospective studies have concluded that initial intra-abdominal pressures of 10 mm Hg or below indicate correct placement of the Veress needle, regardless of the women's body habitus, parity, and age.^{86,87} In fact, another study concluded that the initial gas pressure (≤ 9 mm Hg) is the only accurate measure of correct intraperitoneal Veress needle placement.⁶⁹ Finally, a recent study has confirmed that the initial intraperitoneal insufflation pressure (≤ 10 mm Hg) correlates positively with the patient's weight and BMI and negatively with parity.⁸⁷

Adequate Pneumoperitoneum

Controversy exists as to what defines an "adequate," "appropriate," or "sufficient" pneumoperitoneum prior to insertion of the primary trocar. Traditionally, it has been defined by an arbitrary volume of 1 L to 4 L of CO₂⁷⁴ or an arbitrary intraperitoneal pressure of 10 to 15 mm Hg.⁷⁴ Richardson and Sutton undertook a prospective study of 836 patients undergoing laparoscopy to determine the complications associated with the first entry, using the volume technique ($n = 291$) and the pressure technique ($n = 335$, median pressure 14 mm Hg) as the end points.⁷⁴ The average volume of CO₂ used in the pressure technique group was significantly greater than that used with the volume technique group (4.3 vs. 2.8 L; $P > 0.01$), and the complication rate in the pressure technique group was significantly lower than that in the volume technique group (4.1% vs. 8.2%; $\chi^2 = 5.22$, $df = 1$, $0.5 > P > 0.02$), at all levels of operator experience. The authors suggested that the pressure technique should be universally adopted.⁷⁴

High Pressure Entry (The HIP Entry)

The pressure technique has been adopted by many surgeons worldwide, but the appropriate volume to establish an appropriate intra-abdominal pressure remains controversial. Final pressures up to 10 mm Hg,⁸⁸ 15 mm Hg,^{84,89,90} 14 to 18 mm Hg,⁹¹ 20 mm Hg,^{50,69} and even 25^{48,83,86,92,93} to 30 mm Hg^{93–95} have been advocated.

The rationale for the higher pressure entry technique is that it produces greater splinting of the anterior abdominal wall and a deeper intra-abdominal CO₂ bubble than the traditional volume-limited pneumoperitoneum of 2 L to 4 L. One study determined that 3 L and 4 L of insufflated CO₂ volume established intraperitoneal pressures of 10 and 15 mm Hg, respectively.⁹² The same study demonstrated that when a downward force of 3 kg was applied to an umbilical trocar, the intra-abdominal CO₂ bubble was 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 at least 4 cm deep was maintained in all cases, and the tip of the trocar never touched abdominal contents.⁹² It has been determined that trocar insertion requires 4 to 6 kg of force, and shielded disposable trocars require half the force of reusable trocars.^{96,97}

The combined results of three series involving 8997 laparoscopies using entry pressures of 25 to 30 mm Hg included reports of four (0.04%) bowel injuries^{29,92,95} and one (0.01%) major vessel injury.²⁹ In all cases of bowel injuries, the bowel was adhered at the entry site of the anterior abdominal wall, and the vascular injury occurred because of inadvertent loss of pneumoperitoneum during trocar insertion.

Although the high-pressure entry technique is easier for the surgeon and safer for the patient, surgeons may be reluctant to accept it for fear of compromising the patient's cardiopulmonary function. It has been demonstrated that the use of transient high-pressure pneumoperitoneum causes minor hemodynamic alterations of no clinical significance.^{92,95} However, although there is a significant decrease in pulmonary compliance (approximately 20%) from 15 to 30 mm Hg, the maximum respiratory effects at 25 to 30 mm Hg have not been shown to differ from the effect of Trendelenburg position with intra-abdominal pressure at 15 mm Hg.^{92,95}

Recommendations

1. Left upper quadrant (LUQ, Palmer's) laparoscopic entry should be considered in patients with suspected or known periumbilical adhesions or history or presence of umbilical hernia, or after three failed insufflation attempts at the umbilicus. (II-2 A) Other sites of insertion, such as transuterine Veress CO₂ insufflation, may

be considered if the umbilical and LUQ insertions have failed or have been considered and are not an option. (I-A)

2. The various Veress needle safety tests or checks provide very little useful information on the placement of the Veress needle. It is therefore not necessary to perform various safety checks on inserting the Veress needle; however, waggling of the Veress needle from side to side must be avoided, as this can enlarge a 1.6 mm puncture injury to an injury of up to 1 cm in viscera or blood vessels. (II-1 A)
3. The Veress intraperitoneal (VIP-pressure $\leq$ 10 mm Hg) is a reliable indicator of correct intraperitoneal placement of the Veress needle; therefore, it is appropriate to attach the CO₂ source to the Veress needle on entry. (II-1 A)
4. Elevation of the anterior abdominal wall at the time of Veress or primary trocar insertion is not routinely recommended, as it does not avoid visceral or vessel injury. (II-2 B)
5. The angle of the Veress needle insertion should vary according to the BMI of the patient from 45° in non-obese women to 90° in obese women. (II-2 B)
6. The volume of CO₂ inserted with the Veress needle should depend on the intra-abdominal pressure. Adequate pneumoperitoneum should be determined by a pressure of 20 to 30 mm Hg and not by predetermined CO₂ volume. (II-1 A)
7. In the Veress needle method of entry, the abdominal pressure may be increased immediately prior to insertion of the first trocar. The high intraperitoneal (HIP-pressure) laparoscopic entry technique does not adversely affect cardiopulmonary function in healthy women. (II-1 A)

OPEN LAPAROSCOPIC ENTRY OR HASSON TECHNIQUE

Hasson first described the open entry technique in 1971.¹¹ The suggested benefits are prevention of gas embolism, of preperitoneal insufflation, and possibly of visceral and major vascular injury.

The technique involves using a cannula fitted with a cone-shaped sleeve, a blunt obturator, and possibly a second sleeve to which stay sutures can be attached. The entry is essentially a mini-laparotomy. A small incision is made transversely or longitudinally at the umbilicus. This incision is long enough to be able to dissect down to the fascia, incise it, and enter the peritoneal cavity under direct vision.¹¹ The cannula is inserted into the peritoneal cavity with the blunt obturator in place. Sutures are placed on either side of the cannula in the fascia and attached to the cannula or purse-stringed around the cannula to seal the abdominal wall incision to the cone-shaped sleeve. The laparoscope is then introduced and insufflation is

commenced. At the end of the procedure the fascial defect is closed and the skin is re-approximated. The open technique is favoured by general surgeons and considered by some to be indicated in patients with previous abdominal surgery, especially those with longitudinal abdominal wall incisions.

Several studies on the benefits and complications of the various laparoscopic entry techniques have been published. Hasson reviewed 17 publications of open laparoscopy by general surgeons (9 publications, 7205 laparoscopies) and gynaecologists (8 publications, 13 486 laparoscopies) and compared them with closed laparoscopy performed by general surgeons (7 publications, 90 152 patients) and gynaecologists (12 publications, 579 510 patients).⁷⁶ Hasson reported that for open laparoscopy the rate of umbilical infection was 0.4%, bowel injury 0.1%, and vascular injury 0%. The corresponding rates for closed laparoscopy were 1%, 0.2%, and 0.2%. Hasson advocated the open technique as the preferred method of access for laparoscopic surgery.⁷⁶

Further analysis of Hasson's review suggests that the prospective studies and surveys indicate that general surgeons experience higher complication rates than gynaecologists with the closed technique, but experience similar complication rates with the open technique. Using the closed technique, the visceral and vascular complication rates were 0.22% and 0.04% for general surgeons and 0.10% and 0.03% for gynaecologists. In a published record of his own 29-year experience with laparoscopy in 5284 patients, Hasson reports only one bowel injury within the first 50 cases.⁹⁸

Bonjer et al. published their experience in general surgery and reviewed publications up to 1996 on closed (6 series, $n = 489\ 335$ patients) and open (6 series, $n = 12\ 444$ patients) laparoscopy. The rates of visceral and vascular injury were respectively 0.08% and 0.07% after closed laparoscopy, and 0.05% and 0% after open laparoscopy ($P = 0.002$). Mortality rates after closed and open laparoscopy were respectively 0.003% and 0% (NS).⁹⁹

The Swiss Association for Laparoscopic and Thoracoscopic Surgery (SALTS) prospectively collected data on 90.3% of low-risk patients undergoing various laparoscopic procedures between 1995 and 1997 (14 243 patients, M/F ratio 0.7).¹⁰⁰ The insertion of umbilical trocars caused eight visceral injuries: six after blind insertion and two after Hasson entry. The authors stated that in contrast to findings in general surgery publications by Sigman et al.,²⁸ Bonjer et al.,⁹⁹ and Zaraca et al.,¹⁰¹ the open access method used in the current series failed to show any superiority over the closed establishment of pneumoperitoneum.¹⁰⁰

Garry reviewed six reports ($n = 357\ 257$) of closed laparoscopy and six reports and one survey ($n = 20\ 410$) of open laparoscopy performed by gynaecologists. With the closed entry technique, the rates of bowel and major vessel injury were 0.04% and 0.02%, respectively; with the open entry, they were 0.5% and 0%, respectively. When the survey report ($n = 8000$) was excluded, the rate of bowel injury with the open technique was 0.06%. Garry concluded that open laparoscopy is an acceptable alternative method that has been shown to avoid the risk of injury almost completely in normally situated intra-abdominal structures.²⁹

In its clinical practice guideline on the pneumoperitoneum for laparoscopic surgery, the European Association for Endoscopic Surgery states:

Insertion of the first trocar with the open technique is faster as compared to the Veress needle (grade A).

The randomised controlled trials comparing closed (Veress plus trocar) versus open approach have inadequate sample size to find a difference in serious complications. In large outcomes studies there were less complications in the closed group (grade B). Although RCTs found the open approach faster and associated with a lower incidence of minor complications (grade A), the panel cannot favour the use of either access technique. However, the use of either techniques may have advantages in specific patient subgroups (grade B).⁹⁰

A 2002 meta-analysis of English language studies from both the gynaecological and general surgical literature addresses only major complications defined as bowel or vascular injury.³⁶

The studies reporting complication rates for open laparoscopic entry show that 23 bowel injuries occurred in the course of 21 547 procedures (0.1%) and that one vascular injury occurred in the course of 21 292 procedures (0.005%). The majority of the studies provide only level III evidence as they are primarily mail-in surveys or chart reviews. The findings of this meta-analysis showed that vascular injuries are prevented almost entirely by the open technique (4.7/100 000).³⁶ However, several case reports of vascular injuries with the open technique have been published.^{30,102,103}

Molloy et al.³⁶ also reported a statistically significant difference in bowel complication rates: 0.4/1000 (gynaecologists) versus 1.5/1000 (general surgeons) ($P = 0.001$). When all open laparoscopies were excluded from the analysis, the incidence of bowel injuries was 0.3/1000 in gynaecological procedures and 1.3/1000 in general surgical procedures ($P = 0.001$). The authors speculated that the difference may be due to a variety of confounding variables, including

heterogeneous data, retrospective data, underreporting of adverse events, differences in clinical practices between centres, and patient selection bias. In addition, they pointed out that gynaecologists may have more experience than general surgeons with laparoscopic surgery.³⁶

Bowel injuries are reported more frequently with open laparoscopy than with other techniques (0.11%: 0.04% Veress needle entry, 0.05% direct entry). This may be influenced by patient selection bias, as open procedures may be more likely to be chosen for patients who have had previous abdominal surgery. Another potential bias is that the number of practitioners involved in the reports on open entry is likely much smaller than the number reporting on the Veress needle (open: 21 547 patients, Veress: 134 917 patients). Consequently, practitioner experience is not accounted for.³⁶ The authors conclude that the optimal form of laparoscopic entry in the low-risk patient remains unclear.

Chapron et al. reported on a non-randomized comparison of open versus closed laparoscopic entry practised by university affiliated hospital teams. The bowel and major vessel injury rates were 0.04% and 0.01% in the closed technique ($n = 8324$) and 0.19% and 0% in the open technique ($n = 1562$), respectively. They concluded that open laparoscopy does not reduce the risk of major complications during laparoscopic access.¹⁰⁴

Merlin et al.³³ reported on a systematic review of the various methods used by general surgeons and gynaecologists to establish access for laparoscopic surgery. They noted that retrospective studies compared a high-risk with a low-risk patient population, and prospective studies investigated an unselected patient population. The result was a clear trend towards a reduced risk of major complications in unselected patients undergoing open access procedures.³³ The authors also noted that the most common of the major complications associated with access were bowel injuries. The risk of bowel injury in non-randomized studies was higher with the open technique than with closed technique, although bias introduced through patient selection may have been a factor. Meta-analysis of prospective, non-randomized studies of open versus closed (needle/trocar) access indicated a trend during open access towards a reduced risk of major complications (pooled relative risk [RR_p] 0.30; 95% CI 0.09–1.03). Open access was also associated with a trend towards a reduced risk of access-site herniation (RR_p 0.21; 95% CI 0.04–1.03) and in non-obese patients, a 57% reduced risk of minor complications (RR_p 0.43; 95% CI 0.02–0.92) and a trend for fewer conversions to laparotomy (RR_p 0.21; 95% CI 0.04–1.17). The authors concluded that the evidence on the comparative safety and effectiveness of

the different access methods was not definitive, but trends in the data merit further exploration.³³

A multicentre questionnaire survey of general surgeons (57% responding) reported a relatively high incidence of major injuries; the highest with optical trocars (0.27%), the second highest with the closed technique (0.18%, used 82% of the time), and the lowest with the open technique (0.09%).¹⁰⁵

In clinical trials that compared closed and open entry techniques, the complication rates were 0.07% and 0.17% for the closed and open techniques, respectively.⁸ The authors concluded that, in contrast to the findings of Catarci and colleagues,¹⁰⁵ the number of entry-related complications with the open entry technique was significantly higher than with the closed entry technique. Hasson et al. conclude “There is no evidence to support abandoning the closed entry technique in laparoscopy; however, the selection of patients for an open or alternative procedure is still recommended.”⁸

Finally, Chandler et al.³⁰ reported a study of 594 structures or organs injured during laparoscopic access in 566 patients. They found that bowel injuries were no less common with the open technique and could still be obscure. Eighteen Hasson-type entries were associated with primary entry injuries of the small bowel in four patients, two with delayed recognition and death, and with retroperitoneal vessels in another four patients, one of which resulted in the patient's death. In the remaining 10 patients, there were four instances of colon injuries, three of abdominal wall vessel laceration, and one each of liver, urinary bladder, or mesenteric vessel injury.³⁰

Studies have suggested that 30% to 50% of bowel injuries and 13% to 50% of vascular injuries are undiagnosed at the time of surgery.^{7,30} Because bowel injury is more common than vascular injury, it is more likely to produce serious sequelae because of the delay in diagnosis. The mortality rate from bowel injury is 2.5% to 5%.⁷ Bonjer et al. reported six bowel injuries in 12 444 open laparoscopies, two of which (33%) were not recognized during laparoscopy.⁹⁹ Marret et al. reported delayed recognition of 25/52 (48%) of bowel injuries following optical trocar insertions.⁶⁷

The rate of carbon dioxide embolism was 0.001% in a review of 489 335 closed laparoscopies.⁹⁹ Several case reports have detailed fatal or near-fatal coronary, cerebral, or other gas embolism.^{76,90} Such a complication has not been reported at open laparoscopy.

At this time, there is not convincing evidence that the open entry technique is superior to or inferior to the other entry techniques currently available. The open entry technique does have a lower incidence of vascular injuries, but this is

balanced by a potentially higher incidence of bowel injury, although this can be mitigated if alternative entry sites are chosen in high-risk patients. Instead of dissecting down at the umbilicus on suspected bowel adhesions, an alternative site of entry may be more appropriate, such as the left upper quadrant or the ninth/tenth intercostal spaces. This could possibly decrease the rate of bowel injury, as these sites are rarely affected by adhesions and have been shown to be safe in small studies when hepatosplenomegaly and stomach distension have been excluded.

Recommendation

8. The open entry technique may be utilized as an alternative to the Veress needle technique, although the majority of gynaecologists prefer the Veress entry. There is no evidence that the open entry technique is superior to or inferior to the other entry techniques currently available. (II-2 C)

DIRECT TROCAR ENTRY

Dingfelder was the first to publish (in 1978) on direct entry into the abdomen with a trocar.¹² The suggested advantages of this method of entry are the avoidance of complications related to the use of the Veress needle: failed pneumoperitoneum, preperitoneal insufflation, intestinal insufflation, or the more serious CO₂ embolism.¹⁰⁵ Laparoscopic entry is initiated with only one blind step (trocar) instead of three (Veress needle, insufflation, trocar). The direct entry method is faster than any other method of entry^{106,107}; however, it is the least performed laparoscopic technique in clinical practice today.³⁶

The technique begins with an infra-umbilical skin incision wide enough to accommodate the diameter of a sharp trocar/cannula system. The anterior abdominal wall must be adequately elevated by hand, and the trocar is inserted directly into the cavity, aiming towards the pelvic hollow. Alternatively, the abdominal wall is elevated by pulling on two towel clips placed 3 cm on either side of the umbilicus, and the trocar is inserted at a 90° angle.¹⁰⁷ On removal of the sharp trocar, the laparoscope is inserted to confirm the presence of omentum or bowel in the visual field.³⁷

There are several retrospective studies published on the safety of this method of entry.^{60,73,108–112} Although a few studies were prospective, only three (n = 664 patients) were randomized.^{14,106,107}

The methodology of the three RCTs is sound, and two reported on insertion time as well as morbidity and mortality.^{105,106} Nezhat et al. excluded past abdominal surgery but took into account BMI; they showed fewer minor complications with direct trocar entry than with the Veress needle. No major complications occurred in either group (n = 200

patients).¹⁴ Fewer complications were found with direct trocar insertion, but there was no difference with respect to frequency of multiple attempts or ease of insertion.¹⁴

Byron et al. used the direct entry technique on an unselected group of 937 women. The authors reported more than three attempts to enter the abdomen in 2.7% of cases, failed technique in 1.4%, and a total complication rate of 4.2% (39/937) with a significant increased risk of minor complications ($P < 0.001$). A history of abdominal surgery was not associated with an increased risk of complications.¹³ Subsequently, Byron et al. randomized 252 women into Veress needle (n = 141) and direct trocar insertion (n = 111) for laparoscopy.¹⁰⁶ The authors reported a four-fold increase of minor complications with the Veress needle over the direct entry method (11.3% vs. 2.7%, $P < 0.05$) and a significantly longer insertion time (5.9 vs. 2.2 min, $P < 0.01$). Similarly, Borgatta et al. included women with previous surgery and demonstrated a two-fold increase in omental injury with the Veress needle over the direct trocar insertion and a longer insertion time of 2 minutes and 10 seconds with the Veress needle.¹⁰⁷

Copeland et al. reported on 2000 unselected women with whom direct trocar insertion was utilized. Eight cases (0.4%) required conversion to insufflation with Veress needle, and one of these resulted in bowel injury. Two additional bowel injuries were encountered with the direct trocar entry (0.1%).¹⁰⁹

Hill and Maher perforated the omentum with the direct trocar in 26 of 542 patients (4.8%), as it was elevated with peritoneum.⁷³

Molloy et al. reported on a review of 51 publications including 134 917 Veress/trocar, 21 547 open, and 16 739 direct entries.³⁶ Entry-related bowel injury rates were 0.04% (Veress/trocar), 0.11% (open), and 0.05% (direct entry); corresponding vascular injury rates were 0.04%, 0.01%, and 0%, respectively.³⁶ Case reports of major vessel injury with direct entry have been reported.^{31,103} Five deaths were reported among the studies of case reports, all occurring in the Veress/trocar group. Two deaths were attributable to delayed diagnosis of bowel perforation and three were attributable to gas embolism during insufflation.¹¹³ The calculated overall mortality associated with laparoscopic entry was 1 per 100 000 procedures.³⁶ Bowel injury is reported more frequently in general surgical patients than in gynaecological patients 0.15% versus 0.04% ($P = 0.0001$). Vascular injuries during open and direct entry technique have an identical incidence of 0.0%.³⁶ The authors concluded that “there is no clear evidence as to the optimal form of laparoscopic entry in the low-risk patient. However, direct entry may be an under-utilized and safe alternative to the Veress needle and open entry technique.”³⁶

Sharp trocars are recommended for a direct insertion technique. Reusable trocars are not subject to a standardized frequency of sharpening^{14,27}; this and the strength required to adequately elevate the abdominal wall and to make a controlled forward thrust with the trocar may be limiting factors to the use of this technique. Yuzpe reported that a higher proportion of women than men experienced difficulty inserting both the primary and secondary trocars.²⁷ In addition, injuries appeared to occur twice as often amongst those gynaecologists who experienced difficulty with trocar insertion ($P = 0.04$). When difficulty was associated with the primary trocar, the correlation was even more striking ($P = 0.02$).²⁷

Recommendation

9. Direct insertion of the trocar without prior pneumoperitoneum may be considered as a safe alternative to Veress needle technique. (II-2)

Summary Statement

10. Direct insertion of the trocar is associated with less insufflation-related complications such as gas embolism, and it is a faster technique than the Veress needle technique. (I)

DISPOSABLE SHIELDED TROCARS

Disposable shielded “safety” trocars were introduced in 1984.⁹ These trocars are designed with a shield that partially retracts and exposes the sharp tip as it encounters resistance through the abdominal wall. As the shield enters the abdominal cavity, it springs forward and covers the sharp tip of the trocar.

These trocars were intended to prevent the sharp tip from injuring intra-abdominal contents. However, it must be pointed out that even when a shielded trocar functions properly and is used according to the specifications, there is a brief moment when the sharp trocar tip is exposed and unprotected as it enters the abdominal cavity.^{114,115}

In the presence of pneumoperitoneum, disposable shielded trocars have been shown to require half the force needed for a reusable trocar. The force required to enter the abdomen with various disposable trocars in the pig model was 4 to 6 kg.^{96,116} Increased entry force frequently results in loss of operator control and overthrusting of the trocar, which is a potential cause of serious vascular and visceral injuries.¹¹⁶

In a randomized study of 100 direct laparoscopic entries, no complications occurred with the disposable trocars ($n = 50$), and three (6%) minor complications occurred with the conventional trocars ($P > 0.05$, $\chi^2 1.375$). Ten cases in each group required two insertions, and failed insertion occurred in 8% and 4% of cases ($P > 0.05$, $\chi^2 = 0.177$) in the conventional and disposable trocar groups, respectively.¹⁴

A randomized experimental study in rabbits concluded that initial insufflation was safer than direct trocar insertion; the use of disposable trocars did not improve the safety of the procedure.¹⁵

Champault et al. reported on 103 852 operations involving the use of 386 784 trocars. They found that 10 out of 36 (28%) serious injuries and two out of seven (29%) deaths involved shielded trocars.¹¹⁷ Saville and Woods reported four major retroperitoneal vessel injuries in 3 591 laparoscopies, all of which involved shielded trocars.¹¹⁸

Marret et al. reported 47 complications due to trocar insertions between 1994 and 1997. Half of the trocars used were disposable and this type of so-called safety trocar was responsible for half of the large blood vessel injuries.⁶⁷

Bhojru et al. analyzed 629 trocar injuries reported to the FDA database from 1993 to 1996. There were 408 injuries to major vessels, 182 injuries to other viscera (mainly bowel), and 30 abdominal wall hematomas. Of the 32 deaths, 26 (81%) resulted from visceral injuries, and 6 (19%) resulted from vascular injuries. Eighty-seven percent of deaths from vascular injuries involved the use of disposable trocars with safety shields, and 9% involved disposable optical trocars. Ninety-one percent of bowel injuries involved trocars with safety shields, and 7% involved optical trocars. The diagnosis of bowel injury was delayed in 10% of cases, and the mortality rate in this group was 21%. The authors concluded that safety shields and direct-view trocars cannot prevent serious injuries during laparoscopic access.⁹¹ Furthermore, the data would not support a contention that safety-shield malfunction was a common factor. There were few reports in which a safety-shield malfunction was alleged to have contributed and even fewer in which malfunction was actually found.⁹¹

Corson et al. reviewed 135 entry-related litigated cases in the United States. There were no injuries from reusable trocars, but there were 12 (9%) injuries with shielded trocars. The authors point out that the lack of reusable trocar injuries reflects the popularity of disposable devices in the United States.³¹

Finally, the FDA in a letter to the manufacturers of laparoscopic trocars, dated August 23, 1996, requested that, in the absence of clinical data showing reduced incidence of injuries, manufacturers and distributors voluntarily eliminate safety claims from the labelling of shielded trocars and needles.¹¹⁹

In 1998 and 2000, the Emergency Care Research Institute (ECRI) concluded that although shielded trocars do not totally protect against injuries, they are preferable to unshielded trocars.^{114,115} A trocar use survey of 62 health care facilities reported that shielded trocars were used for

primary trocar entry by 37% of surgeons for 100% of procedure, by 59% for at least 90% of procedures, and by 79% for at least 80% of procedures.¹²⁰

Recommendation

11. Shielded trocars may be used in an effort to decrease entry injuries. There is no evidence that they result in fewer visceral and vascular injuries during laparoscopic access. (II-B)

RADIALLY EXPANDING ACCESS SYSTEM

The radially expanding access system (Step, InnerDyne, Sunnyvale, CA) was introduced in 1994. It consists of a 1.9 mm Veress surrounded by an expanding polymeric sleeve. The abdomen may first be insufflated using the Veress needle. The needle is removed, and the sleeve acts as a tract through the abdominal wall that can be dilated up to 12 mm by inserting a blunt obturator with a twisting motion.^{21,121,122} The force required to push this trocar through the abdomen in pigs is 14.2 kg compared with forces of 4 to 6 kg needed for disposable trocars.¹¹⁶

Several case series and randomized studies have reported no injury to major vessels and no deaths.²¹ Abdominal wall bleeding and Veress injury to mesentery have been encountered.²¹ In addition, RCTs have demonstrated less post-operative pain and more patient satisfaction with the radially expanding device than with the conventional trocar entry techniques.^{123–126}

Advantages of this system include elimination of sharp trocars, application of radial force, stabilization of the cannula's position (cannula does not slide in and out), avoidance of injury to abdominal wall vessels, and elimination of the need for suturing of fascial defects.

Recommendation

12. Radially expanding trocars are not recommended as being superior to the traditional trocars. They do have blunt tips that may provide some protection from injuries, but the force required for entry is significantly greater than with disposable trocars. (I-A)

VISUAL ENTRY SYSTEMS

Disposable Optical Trocars

Optical/access trocars were introduced in 1994⁹ and are popular among urologists. Two disposable visual entry systems are available that retain the conventional trocar and cannula push-through design: the Endopath Optiview optical trocar (Ethicon Endo-Surgery, Inc., Cincinnati, OH) and The Visiport optical trocar, (Tyco-United States Surgical, Norwalk, CT). These single-use visual trocars trade blind sharp trocars for a hollow trocar, in which a zero

degree laparoscope is loaded for the distal crystal tip to transmit real-time monitor images while transecting abdominal wall tissue layers. Their application recruits significant axial thrust through the surgeon's dominant upper body muscles to transect abdominal myofascial layers.

Endopath Optiview optical trocar

The Endopath Optiview optical trocar comprises a hollow trocar and a cannula. When insufflation is complete, the Veress needle is withdrawn, and the subcutaneous fatty tissue is dissected off, using peanut sponges, to expose the white anterior rectus fascia. A 5 mm incision is then made with a scalpel to accommodate the visual trocar's pointed tip.

When the Endopath optical trocar is used directly, without pre-insufflation, two anterior rectus fascia stay sutures are placed at 3 and 9 o'clock and held with snaps. The fascia is then divided between the stay sutures over a length of approximately 5 mm. During insertion, the stay sutures are pulled to lift the abdominal wall against the advancing trajectory and facilitate proper port site closure at the end of the operation. Alternatively, the assistant may grasp the abdominal wall with towel clips, while the surgeon negotiates the visual trocar.¹²⁷

Twisting the handle advances the hydrophobic and winged trocar tip to dissect successive tissue layers on its way towards the abdomen. The cascade of generated entry images displayed on the monitor demonstrates level of penetration.

Some surgeons advocate use of visual trocars during gasless laparoscopy, in which abdominal wall lifting devices are used to tent the abdominal wall before the primary visual trocar is inserted under visual control. Experience with such methods is limited, and large-scale studies are lacking.¹²⁸

The retention of the push-through trocar design necessitates considerable axial force to propel the trajectory, with no mechanism to offset overshoot. Given the winged trocar tip, the generated axial force dents tissue layers, and compression renders layer recognition more difficult.¹²⁷

Visiport optical trocars

The Visiport optical trocar is a disposable visual entry instrument that comprises a hollow trocar and a cannula. Every trigger squeeze advances the sharp cutting knife 1 mm to transect tissue in contact with the crystal tip and swiftly retract back into the crystal hemisphere. It is advised that, as with other visual trocars, the Visiport optical trocar is to be applied only after CO₂ insufflation.¹²⁹

When insufflation is complete, the Veress needle is withdrawn, and subcutaneous fatty tissue is dissected off the white anterior rectus fascia using peanut sponges. The Visiport optical trocar is palmed by the surgeon's dominant hand and held perpendicular to the supine patient's CO₂

distended abdomen. Once the exact anatomical position of the trocar tip is verified on the monitor, downward axial pressure is applied while activating the trigger. Then downward pressure is relieved, the trigger released, and the trocar tip position verified on the monitor again. This entry sequence is repeated until the peritoneal cavity is entered. The trigger is not fired until the exact anatomical position of the trocar tip is known.

The push-through entry design requires significant perpendicular force to drive a trajectory across tissue planes with no means of avoiding trocar overshoot. Sometimes, the anterior abdominal wall may be grasped with the non-dominant hand of the surgeon and lifted to offer counter pressure against the advancing trocar. The Visiport optical trocar comes in only one diameter and accommodates only a 10 mm laparoscope.

EndoTIP visual cannula

The endoscopic threaded imaging port, EndoTIP (Karl STORZ Endoscopy, Tuttlingen, Germany), is a reusable visual cannula system that allows real-time interactive port creation, when port-dynamics are archived, for recall and analysis. The principal differentiating aspects of EndoTIP include reduction of push-force, visually controlled entry, elimination of overshoot, and lack of sharp trocar.

Conventional primary trocar insertion requires application of considerable axial push-force (2–14 kg)^{96,97} to the trocar and cannula where the anterior abdominal wall dents towards the viscera; entry is blind. The EndoTIP consists of a stainless steel cannula with a proximal valve segment and distal hollow threaded cannula section. The conventional valve sector houses a standard CO₂ stopcock, and the cannula's outer surface is wrapped with a single thread, winding diagonally to end in a distal blunt notched tip. The cannula is available in different lengths and diameters for different surgical applications. A retaining ring keeps the mounted laparoscope from sliding out of focus during insertion.¹³⁰

The EndoTIP visual cannula system requires no trocar and has no crystal tip compressing and distorting monitor images at tissue–cannula interface. Interpretations of observed monitor images are identified, layered-entry, and real-time interactive.

A generous umbilical skin incision is made using a surgical blade to avoid skin dystonia. Ribbon retractors and peanut sponges are used to expose the white anterior rectus fascia. As when using the optical trocar, insertion starts at the fascial level. A 7 mm rectus fascial incision is then made under direct vision, and the Veress needle is inserted through the fascial incision with the CO₂ stopcock in the open position.

When insufflation is complete, the surgeon holds the laparoscope with mounted cannula perpendicular to patient's supine abdomen, using the non-dominant hand. The unit, (laparoscope and mounted cannula) with the CO₂ stopcock in the closed position is then lowered into the umbilical wound. The surgeon uses the muscles of the dominant wrist to rotate the cannula clockwise, while keeping the forearm horizontal to the patient's abdomen. Downward axial pressure during rotation is kept to a minimum.

The blunt cannula's notched tip engages the anterior rectus fascial window and stretches it radially. Rotation applies Archimedes' principle to lift the anterior abdominal wall and transpose successive tissue layers onto the cannula's outer thread. The white anterior rectus fascia, red rectus muscle, pearly white posterior rectus fascia, yellowish preperitoneal space, and transparent greyish peritoneal membrane are all observed sequentially on the monitor.

As the cannula has no cutting or sharp end, tissue layers are not transected; instead, they are taken up along the outer pitch. The parted tissue layers preserve port competence and result in a smaller fascial entry wound area with less muscle damage than with pyramidal trocar wounds.¹³¹

Further clockwise rotation parts the peritoneal membrane radially to advance the cannula incrementally into the peritoneal cavity under direct visual control, while avoiding cannula overshoot.

Recommendation

13. The visual entry cannula system may represent an advantage over traditional trocars, as it allows a clear optical entry, but this advantage has not been fully explored. The visual entry cannula trocars have the advantage of minimizing the size of the entry wound and reducing the force necessary for insertion. Visual entry trocars are non-superior to other trocars since they do not avoid visceral and vascular injury. (2 B)

REFERENCES

1. Chapron C, Fauconnier A, Goffinet F, Breart G, Dubuisson JB. Laparoscopic surgery is not inherently dangerous for patients presenting with benign gynecologic pathology: results of a meta-analysis. *Hum Reprod* 2002;17:1334–42.
2. Medeiros LR, Fachel JMG, Garry R, Stein AT, Furness S. Laparoscopy versus laparotomy for benign ovarian tumours. *The Cochrane Database of Systematic Reviews* 2005;Issue 3:Art. No. CD004751. pup2. DOI:10.1002/14651858.
3. Jansen FW, Kapiteyn K, Trimbo-Kemper T, Hermans J, Trimbo JB. Complications of laparoscopy: a prospective multicentre observational study. *Br J Obstet Gynaecol* 1997;104:595–600.
4. Harkki-Siren P, Kurki T. A nationwide analysis of laparoscopic complications. *Obstet Gynecol* 1997;89:108–12.
5. Chapron CM, Pierre F, Lacroix S, Querleu D, Lansac J, Dubuisson JB. Major vascular injuries during gynecologic laparoscopy. *J Am Coll Surg* 1997;185:461–5.

6. Nuzzo G, Giuliani F, Tebala GD. Routine use of open technique in laparoscopic operations. *J Am Coll Surg* 1997;184:58–62.
7. Magrina J. Complications of laparoscopic surgery. *Clin Obstet Gynecol* 2002;45:469–80.
8. Jansen FW, Kolkman W, Bakkuim EA, de Kroon CD, Trimbos-Kemper TCM, Trimbos JB. Complications of laparoscopy: an inquiry about closed versus open-entry technique. *Am J Obstet Gynecol* 2004;190:634–8.
9. Fuller J, Scott W, Ashar B, Corrado J. Laparoscopic trocar injuries: a report from a U.S. Food and Drug Administration (FDA) Center for Devices and Radiological Health (CDRH) Systematic Technology Assessment of Medical Products (STAMP) Committee. 8/25/2005;1–14. Available at: <http://www.fda.gov/cdrh/medicaldevicesafety/stamp/trocar.html>. Accessed April 4, 2007.
10. Palmer R. Safety in laparoscopy. *J Reprod Med* 1974;13:1–5.
11. Hasson HM. A modified instrument and method for laparoscopy. *Am J Obstet Gynecol* 1971;110:886–7.
12. Dingfelder JR. Direct laparoscopic trocar insertion without prior pneumoperitoneum. *J Reprod Med* 1978;21:45–7.
13. Byron JW, Fujiyoshi CA, Miyazawa K. Evaluation of the direct trocar insertion technique at laparoscopy. *Obstet Gynecol* 1989;74:423–5.
14. Nezhat FR, Silfen SL, Evans D, Nezhat C. Comparison of direct insertion of disposable and standard reusable laparoscopic trocars and previous pneumoperitoneum with Veress needle. *Obstet Gynecol* 1991;78:148–50.
15. Lanvin D, Elhage A, Querleu D. Does the use of pneumoperitoneum and disposable trocars prevent bowel injury at laparoscopy? A randomized experimental study in the rabbit. *Gynaecol Endosc* 1996;5:343–8.
16. Riek S, Bachmann KH, Gaiselmann T, Hoernstein F, Marzusch K. A new insufflation needle with a special optical system for use in laparoscopic procedures. *Obstet Gynecol* 1994;84:476–8.
17. McGurgan P, O'Donovan P. Optical Veress as an entry technique. *Gynaecol Endosc* 1999;8:379–92.
18. Kaali SG. Introduction of the Opti-Trocar. *J Am Assoc Gynecol* 1993;1:50–3.
19. Mettler L, Schmidt EH, Frank V, Semm K. Optical trocar systems: laparoscopic entry and its complications (a study of case in Germany). *Gynaecol Endosc* 1999;8:383–9.
20. Turner DJ. A new radially expanding access system for laparoscopic procedures versus conventional cannulas. *J Am Assoc Gynecol Laparosc* 1996;34:609–15.
21. Turner DJ. Making the case for the radially expanding access system. *Gynaecol Endosc* 1999;8:391–5.
22. Ternamian AM. Laparoscopy without trocars. *Surg Endosc* 1997;11:8159–68.
23. Ternamian AM. A second-generation laparoscopic port system: EndoTIP™. *Gynaecol Endosc* 1999;8:397–401.
24. Woolf SH, Battista RN, Angerson GM, Logan AG, Eel W. Canadian Task Force on Preventive Health Care. New grades for recommendations from the Canadian Task Force on Preventive Health Care. *Can Med Assoc J* 2003;169(3):207–8.
25. Harrell AG, Heniford BT. Minimally invasive abdominal surgery: lux et veritas past, present, and future. *Am J Surg* 2005;190:239–43.
26. Gomel V, Taylor PJ, Yuzpe AA, Rioux JE. *Laparoscopy and Hysteroscopy in Gynecologic Practice*. Chicago: Year Book Medical Publishers; 1986.
27. Yuzpe AA. Pneumoperitoneum needle and trocar injuries in laparoscopy: a survey on possible contributing factors and prevention. *J Reprod Med* 1990;35:485–90.
28. Sigman HH, Fried GM, Garzon J, Hinchey EJ, Wexler MJ, Meakins JL. Risks of blind versus open approach to celiotomy for laparoscopic surgery. *Surg Laparosc Endosc* 1993;3:296–9.
29. Garry R. Towards evidence based laparoscopic entry techniques: clinical problems and dilemmas. *Gynaecol Endosc* 1999;8:315–26.
30. Chandler JG, Corson SL, Way LW. Three spectra of laparoscopic entry access injury. *J Am Coll Surg* 2001;192:478–91.
31. Corson SL, Chandler JG, Way LW. Survey of laparoscopic entry injuries provoking litigation. *J Am Assoc Gynecol Laparosc* 2001;8:341–7.
32. Lingam K, Cole R. Laparoscopy entry port visited: a survey of practices of consultant gynaecologists in Scotland. *Gynaecol Endosc* 2001;10:335–42.
33. Merlin T, Hiller J, Maddern G, Jamieson GG, Brown AR, Kolbe A. Systematic review of the safety and effectiveness of methods used to establish pneumoperitoneum in laparoscopic surgery. *Br J Surg* 2003;90:668–70.
34. Rosen DM, Lam AM, Chapman M, Carlton M, Cario GM. Methods of creating pneumoperitoneum: a review of techniques and complications. *Obstet Gynecol Surv* 1998;53(3):167–74.
35. Munro MG. Laparoscopic access: complications, technologies and techniques. *Curr Opin Obstet Gynecol* 2002;14:365–74.
36. Molloy D, Kalloo PD, Cooper M, Nguyen TV. Laparoscopic entry: a literature review and analysis of techniques and complications of primary port entry. *Aust NZJ Obstet Gynaecol* 2002;42:246–54.
37. Brill AJ, Cohen BM. Fundamentals of peritoneal access. *J Am Assoc Gynecol Laparosc* 2003;10:287–97.
38. Hurd WW, Bude RO, De Lancey JOL, Pearl ML. The relationship of the umbilicus to the aortic bifurcation: complications for laparoscopic technique. *Obstet Gynecol* 1992;80:48–51.
39. Nezhat F, Brill AJ, Nezhat C, Nezhat A, Seidman DS, Nezhat CH. Laparoscopic appraisal of the anatomic relationship of the umbilicus to the aortic bifurcation. *J Am Assoc Gynecol Laparosc* 1998;5(2):135–40.
40. Hurd WW, Bude RD, De Lancey JOL, Gavin JM, Aisen AM. Abdominal wall characterization with magnetic resonance imaging and computed tomography: the effect of obesity in the laparoscopic approach. *J Reprod Med* 1991;26:473–6.
41. Tulikangas RK, Nicklas A, Falcone T, Price LL. Anatomy of the left upper quadrant for cannula insertion. *J Am Assoc Gynecol Laparosc* 2000;7:211–4.
42. Cohen MR, Scoccia B. Double laparoscopy: an alternative two-stage procedure to minimize bowel and blood vessel injury. *J Gynecol Surg* 1991;7:203–6.
43. Childers JM, Brzechffa PR, Surwit EA. Laparoscopy using the left upper quadrant as the primary trocar site. *Gynecol Oncol* 1993;50:221–5.
44. Lang PFJ, Tamussino K, Honigl W. Palmer's point: an alternative site for inserting the operative laparoscope in patients with intra-abdominal adhesions. *Gynaecol Endosc* 1993;2:35–7.
45. Howard FM, El-Minawi AM, DeLoach VE. Direct laparoscopic cannula insertion at the left upper quadrant. *J Am Assoc Gynecol Laparosc* 1997;4:595–600.
46. Patsner B. Laparoscopy using the left upper quadrant approach. *J Am Assoc Gynecol Laparosc* 1999;6:323–5.
47. Audebert AJ, Gomel V. Role of microlaparoscopy in the diagnosis of peritoneal and visceral adhesions and in the prevention of bowel injury associated with blind trocar insertion. *Fertil Steril* 2000;73:631–5.
48. Lam KW, Pun TL. Left upper quadrant approach in gynecologic laparoscopic surgery with reusable instruments. *J Am Assoc Gynecol Laparosc* 2002;9:199–203.
49. Golan A, Sagiv R, Debby A, Glezerman M. The minilaparoscope as a tool for localization and preparation for cannula insertion in patients with multiple previous abdominal incisions or umbilical hernia. *J Am Assoc Gynecol Laparosc* 2003;10:14–6.

50. Agarwala N, Liu CY. Safe entry technique during laparoscopy: left upper quadrant entry using the ninth intercostal space: a review of 918 procedures. *J Minim Invasive Gynecol* 2005;12:55–61.
51. Sanders RR, Filshie GM. Transfundal induction of pneumoperitoneum prior to laparoscopy. *J Obstet Gynaecol Br Cmwlt* 1994;107:316–7.
52. Morgan HR. Laparoscopy: induction of pneumoperitoneum via transfundal puncture. *Obstet Gynecol* 1979;54:260–1.
53. Wolfe WM, Pasic R. Transuterine insertion of Veress needle in laparoscopy. *Obstet Gynecol* 1990;75:456–7.
54. Trivedi AN, MacLean NE. Transuterine insertion of Veress needle for gynecological laparoscopy at Southland Hospital. *NZ Med J* 1994;107:316–7.
55. Pasic R, Levine RL, Wolfe WM Jr. Laparoscopy in morbidly obese patients. *J Am Assoc Gynecol* 1999;6:307–12.
56. Santala M, Jarvela I, Kauppila A. Transfundal insertion of a Veress needle in laparoscopy of obese subjects: a practical alternative. *Hum Reprod* 1999;14:2277–8.
57. Neely MR, McWilliams R, Makhlof HA. Laparoscopy: routine pneumoperitoneum via the posterior fornix. *Obstet Gynecol* 1975;45:459–60.
58. van Lith DA, van Schie KJ, Beekhuizen W, du Plessis M. Cul-de-sac insufflation: an easy alternative route for safely inducing pneumoperitoneum. *Int J Gynaecol Obstet* 1980;17:375–8.
59. Reich H, Levie L, McGlynn F, Sekel L. Establishment of pneumoperitoneum through the left ninth intercostal space. *Gynaecol Endosc* 1995;4:141–3.
60. Kaali SG, Barad DH. Incidence of bowel injury due to dense adhesions of direct trocar insertions. *J Reprod Med* 1992;27:617–8.
61. Levrant SG, Bieher EJ, Barnes RB. Anterior abdominal wall adhesions after laparotomy or laparoscopy. *J Am Assoc Gynecol Laparosc* 1997;4(3):353–6.
62. Brill A, Nezhat F, Nezhat CH, Nezhat C. The incidence of adhesions after prior laparotomy: A laparoscopic appraisal. *Obstet Gynecol* 1995;85:269–72.
63. Painvain E, De Pascale A, Carillo C, Dalla Torre A, Bonomo A. Preoperative ultrasonic detection of abdominal wall adhesions in laparoscopic surgery. *Gynaecol Endosc* 1995;4:265–8.
64. Kolecki RV, Golub RM, Sigel B, Machi J, Kimatura H, Hosokawa T, et al. Accuracy of visceral slide detection of abdominal adhesions by ultrasound. *Surg Endosc* 1994;8:871–4.
65. Fear RE. Laparoscopy: a valuable aid in gynecologic diagnosis. *Obstet Gynecol* 1968;31:297–309.
66. Lacey CG. Laparoscopy: a clinical sign for intraperitoneal needle placement. *Obstet Gynecol* 1976;47:625–7.
67. Marret H, Harchaoui Y, Chapron C, Lansac J, Pierre F. Trocar injuries during laparoscopic gynaecological surgery. Report from the French Society of Gynecological Laparoscopy. *Gynaecol Endosc* 1998;7:235–41.
68. Semm K, Semm I. Safe insertion of trocars and Veress needle using standard equipment and the 11 security steps. *Gynaecol Endosc* 1999;8:339–47.
69. Teoh B, Sen R, Abbott J. An evaluation of four tests used to ascertain Veress needle placement at closed laparoscopy. *J Minim Invasive Gynecol* 2005;12:153–8.
70. Brosens I, Gordon A. Bowel injuries during gynaecological laparoscopy: a multinational survey. *Gynaecol Endosc* 2001;10:141–5.
71. Roy GM, Bazzurini L, Solima E, Luciano AA. Safe technique for laparoscopic entry into the abdominal cavity. *J Am Assoc Gynecol Laparosc* 2001;8(4):519–28.
72. Corson SL, Brooks PG, Soderstrom RM. Safe technique for laparoscopic entry into the abdominal cavity [Letter]. *J Am Assoc Gynecol Laparosc* 2002;9:399–401.
73. Hill DJ, Maher PJ. Direct cannula entry for laparoscopy. *J Am Assoc Gynecol Laparosc* 1996;4(1):77–9.
74. Richardson RF, Sutton CJG. Complications of first entry: a prospective laparoscopic audit. *Gynaecol Endosc* 1999;8:327–34.
75. Mumford ST, Bhiwandiwala PP, Chang C. Laparoscopic and minilaparotomy female sterilization compared in 15,617 cases. *Lancet* 1980;ii:1066–70.
76. Hasson HM. Open laparoscopy as a method of access in laparoscopic surgery. *Gynaecol Endosc* 1999;8:353–62.
77. Kabukoba JJ, Skillren LH. Coping with extraperitoneal insufflation during laparoscopy: a new technique. *Obstet Gynecol* 1992;80:144–5.
78. Janicki TI. The new sensor-equipped Veress needle. *J Am Assoc Gynecol Laparosc* 1994;1(2):154–6.
79. Noorani M, Noorani K. Pneumoperitoneum under vision—a new dimension in laparoscopy. *Endo World* 1997;39-E:1–8.
80. Meltzer A, Weiss U, Roth K, Loeffler M, Buess G. Visually controlled trocar insertion by means of the optical scalpel. *Endosc Surg Allied Technol* 1993;1:239–42.
81. Schaller G, Kuenkel M, Manegold BC. The optical Veress needle initial puncture with a minioptic. *Endosc Surg Allied Technol* 1995;3:55–7.
82. Parker J, Reid G, Wong F. Microlaparoscopic left upper quadrant entry in patients at high risk of periumbilical adhesions. *Aust NZJ Obstet Gynecol* 1999;39(11):88–92.
83. Garry R. Complications of laparoscopic entry [editorial review]. *Gynaecol Endosc* 1997;6:319–29.
84. Dubuisson JB, Chapron C, Decuypere F, De Spirlet M. ‘Classic’ laparoscopic entry in a university hospital: a series of 8324 cases. *Gynaecol Endosc* 1999;8:349–52.
85. Ricci M, Aboolian A. Needle pneumoperitoneum. An alternative technique. *Surg Endosc* 1999 Jun;13(6):629.
86. Vilos GA, Vilos AG. Safe laparoscopic entry guided by Veress needle CO2 insufflation pressure. *J Am Assoc Gynecol Laparosc* 2003;10:415–20.
87. Vilos AG, Vilos GA, Abu-Rafea B, Hollet-Caines J, Al-Omran M. Effect of body habitus and parity on the initial Veres intraperitoneal (VIP) CO2 insufflation pressure during laparoscopic access in women. *J Minim Invasive Gynecol* 2006;13(2):108–13.
88. Thompson JD, Rock JA. Diagnostic and operative laparoscopy. In: Rock JA, Jones HW. *TeLinde's Operative Gynecology*. 7th ed. Philadelphia: Lippincott; 1991:363.
89. Nordestgaard AG, Bodily KC, Osborne RW, et al. Major vascular injuries during laparoscopic procedures. *Am J Surg* 195;169:543–5.
90. Neudecker J, Sauerland S, Nengebauer F, Bergamaschi R, Bonjer HJ, Cuschieri A. The European Association for Surgery Clinical Practice Guideline on the pneumoperitoneum for laparoscopic surgery. *Surg Endosc* 2002;16:1121–43.
91. Bhoyrul S, Vierra MA, Nezhat CR, Krummel TM, Way LW. Trocar injuries in laparoscopic surgery. *J Am Coll Surg* 2001;192:677–83.
92. Phillips G, Garry R, Kumar C, Reich H. How much gas is required for initial insufflation at laparoscopy? *Gynaecol Endosc* 1999;8:369–74.
93. Reich H, Ribeiro SC, Rasmussen C, Rosenberg J, Vidali A. High-pressure trocar insertion technique. *J Laparoendosc Adv Surg Tech A* 1999;3:45–8.
94. Reich H, Rasmussen C, Vidali A. Peritoneal hyperdistention for trocar insertion. *Gynaecol Endosc* 1999;8:375–7.

95. Abu-Rafea B, Vilos GA, Vilos AG, Ahmad R, Hollett-Caines J. High pressure laparoscopic entry does not adversely affect cardiopulmonary function in healthy women. *J Minim Invasive Gynecol* 2005;12:475–9.
96. Corson SL, Batzer FR, Gocial B, et al. Measurements of the force necessary for laparoscopic entry. *J Reprod Med* 1994;34:282–4.
97. Tarney CM, Glass K, Munro MG. Entry force and intra-abdominal pressure associated with six laparoscopic trocar cannula systems: a randomized comparison. *Obstet Gynecol* 1999;94:83–8.
98. Hasson HM, Rotman C, Rana N, Kumari NA. Open laparoscopy: 29-year experience. *Obstet Gynecol* 2000;96:63–6.
99. Bonjer HJ, Hazebroek EJ, Kazemier G, Giuffrida MC, Meijer WS, Lange JF. Open versus closed establishment of pneumoperitoneum in laparoscopic surgery. *Br J Surg* 1997;84:599–602.
100. Schafer M, Lauper M, Krahenbuhl L. Trocar and Veress needle injuries during laparoscopy. *Surg Endosc* 2001;15:275–80.
101. Zaraca F, Catarci M, Gosselti F, Mulieri G, Carboni M. Routine use of open laparoscopy: 1,006 consecutive cases. *J Laparoendosc Adv Surg Tech A* 1999;9:75–80.
102. Hanney RM, Carmalt HL, Merrett N, Tait N. Use of the Hasson cannula producing major vascular injury at laparoscopy. *Surg Endosc* 1999;13:1238–40.
103. Vilos GA. Litigation of laparoscopic major vessel injuries in Canada. *J Am Assoc Gynecol Laparosc* 2000;7:503–9.
104. Chapron C, Cravello L, Chopin N, Kreiker G, Blanc B, Dubuisson JB. Complications during set-up procedures for laparoscopy in gynecology: open laparoscopy does not reduce the risk of major complications. *Acta Obstet Gynecol Scand* 2003;82:1125–9.
105. Catarci M, Carlini M, Gentileschi P, Santoro E, for the Lap Group Roma. Major and minor injuries during the creation of pneumoperitoneum: a multicenter study on 12,919 cases. *Surg Endosc* 2001;15:566–9.
106. Byron JW, Markenson G, Miyazawa K. A randomized comparison of Veress needle and direct trocar insertion for laparoscopy. *Surg Gynecol Obstet* 1993;177:259–62.
107. Borgatta L, Gruss L, Barad D, Kaali SG. Direct trocar insertion vs Veress needle use for laparoscopic sterilization. *J Reprod Med* 1990;35:891–4.
108. Jacobson MT, Osias J, Bizhang R, Tsang M, Lata S, Helmy M. The direct trocar technique: an alternative approach to abdominal entry for laparoscopy. *J SLS* 2002;6:169–74.
109. Copeland C, Wing R, Hulka JF. Direct trocar insertion at laparoscopy: an evaluation. *Obstet Gynecol* 1983;62:655–9.
110. Saidi SH. Direct laparoscopy without prior pneumoperitoneum. *J Reprod Med* 1986;31:684–6.
111. Jarett JC. Laparoscopy: direct trocar insertion without pneumoperitoneum. *Obstet Gynecol* 1990;75:725–7.
112. Woolcot R. The safety of laparoscopy performed by direct trocar insertion and carbon dioxide insufflation under vision. *Aus NZ J Obstet Gynaecol* 1997;37:216–9.
113. Mintz M. Risks and prophylaxis in laparoscopy: A survey of 100 000 cases. *J Reprod Med* 1977;18:269–72.
114. Emergency Care Research Institute (ECRI). Trocars and selection. *Health devices* 1998;27:376–98.
115. Emergency Care Research Institute (ECRI). A brief recap: trocars and their use. *Health devices* 2000;29:68–71.
116. Tarnay CM, Glass KB, Munro MG. Entry force and intra-abdominal pressure associated with six laparoscopic trocar cannula systems: a randomized comparison. *Obstet Gynecol* 1999;94:83–8.
117. Champault G, Cazacu F, Taffinder N. Serious trocar accidents in laparoscopic surgery: A French survey of 103 852 operations. *Surg Laparosc Endosc* 1996;6:367–70.
118. Saville LE, Woods MS. Laparoscopy and major retroperitoneal vascular injuries (MRVI). *Surg Endosc* 1995;9:1096–1100.
119. Wells T. Shielded trocars and needles used for abdominal access during laparoscopy. Rockville, MD: Department of Health and Human Services; 1996.
120. Trocars: New data on safety and selection. *Health devices* 2000;29(2–3):67–71.
121. Bhojyul S, Mori T, Way LW. A safer cannula design for laparoscopic surgery: Results of a comparative study. *Surg Endosc* 1995;9:227–9.
122. Turner DJ. A new radially expanding access system for laparoscopic procedures versus conventional cannulas. *J Am Assoc Gynecol Laparosc* 1996;3:609–15.
123. Yim SF, Yuen PM. Randomized double-masked comparison of radially expanding access device and conventional cutting tip trocar in laparoscopy. *Obstet Gynecol* 2001;97:435–8.
124. Lam TY, Lee SW, So HS, Kwok SP. Radially expanding trocars: a less painful alternative for laparoscopic surgery. *J Laparoendosc Adv Surg Tech A*. 2000; 19(5): 269–73.
125. Bhojyul S, Payne J, Steffes B, Swannstrom L, Way LW. A randomized prospective study of radially expanding trocars in laparoscopic surgery. *J Gastrointest Surg* 2000;4:392–7.
126. Feste JR, Bojahr B, Turner DJ. Randomized trial comparing a radially expandable needle system with cutting trocars. *J Soc Laparosc Endosc Surg* 2000;4:11–5.
127. McKernan J, Finley C. Experience with optical trocar in performing laparoscopic procedures. *Surg Laparosc Endosc* 2002;12:96–9.
128. Angelini L, Lirici M, Papaspyropoulos V, Sossi F. Combination of subcutaneous abdominal wall retraction and optical trocar to minimize pneumoperitoneum-related effects and needle and trocar injuries in laparoscopic surgery. *Surg Endosc* 1997;11:1006–9.
129. Visiport Optical Trocar information booklet [Internet]. Norwalk CT: AutoSuture. Available at: <http://www.autosuture.com/AutoSuture/pagebuilder.aspx?contentID=39263&topicID=31737&breadcrumbs=0:63659,30780:0,65365:0#>. Accessed April 4, 2007.
130. Ternamian AM. How to improve laparoscopic access safety: ENDOTIP. *Min Invas Ther & Allied Technol* 2001;10:31–9.
131. Glass KB, Tarnay CM, Munro MG. Intraabdominal pressure and incision parameters associated with a pyramidal laparoscopic trocar-cannula system and the EndoTIP cannula. *J Am Assoc Gynecol Laparosc* 2002;9:508–13.