Low-pressure and Gasless Laparoscopy in Abdominal Surgery

ABSTRACT

Knowledge of pathophysiological basis of laparoscopic procedures, that is, the influence of CO₂ pneumoperitoneum (PNP) on the body in particular, can prevent the complications during laparoscopy to occur. Standard intra-abdominal pressure (IAP), which is used during laparoscopic surgery, is 12-15 mm / Hg. The direct effect of CO₂ pneumoperitoneum is a result of mechanical action of the gas and increase of intra-abdominal pressure (IAP). The indirect effect of CO₂ pneumoperitoneum is caused by the absorption of gas inserted into the abdomen. Analysis of published articles that assess the effects of CO₂ pneumoperitoneum on the body and abdominal organs contributes to a better usage of the laparoscopic method. Different techniques in laparoscopy, created as an alternative to standard CO₂-pneumoperitoneum, have the task to reduce the risks for patients with comorbidity and simultaneously raise the abdominal wall and allow the surgeon to perform smooth operation, which is especially important for ASA III and ASA IV patients. Alternative techniques can be divided into three groups: laparoscopy using pneumoperitoneum with low intra-abdominal pressure (up to 8 mm / Hg), laparoscopy using retractors abdominal wall and limited pneumoperitoneum, and laparoscopy without the use of gas (gasless laparoscopy; raising the abdominal wall retractor only). Low insufflation pressure in the abdomen (up to 8 mm / Hg) is beneficial for patients with laparoscopic procedures and its routine usage in elderly patients and patients with severe cardiorespiratory diseases, should be common practice. Gasless laparoscopy was created because of the need to prevent the negative effects of increased intra-abdominal pressure on the body during laparoscopy, primarily in patients with high comorbidity (ASA III and ASA IV). When compared to other techniques, numerous studies prefer laparoscopy with low insufflation pressure, but in practice this is not done routinely, yet each technique is applied selectively, according to the needs and condition of the patient, which is the most appropriate. To avoid the side effects of CO₂ pneumoperitoneum, which is important in high-risk patients, it is more likely to operate on low IAP (6-8 mm / Hg) or use gasless laparoscopy. This is especially important for long – duration operations.

Contact address:

Šefik Hasukić, PhD
Department of Surgery,
University Hospital Clinical Centre
Tuzla
Trnovac bb
75000 Tuzla
Bosnia and Herzegovina
Phone: + 387 35 303 129
Fax: + 387 35 250 474
email: shasukic@bih.net.ba

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Introduction

Controlled insufflation pressure within the abdominal cavity has the task to enable the smooth operation to the surgeon, lifting the front abdominal wall up and pushing other abdominal organs and soft tissues back. CO₂ gas is considered to be the most appropriate for insufflation into the abdominal cavity, as it fulfills several important criteria: it is non-flammable and it is possible to use electrocauter.

Moreover, it is very soluble in blood and tissues, and may be easily ejected through the lungs, it is nontoxic and very inexpensive (Table 1.). Other gases such as argon, helium and NO₂, have been used experimentally and have not closely met the above requirements, and are therefore rarely used.^{1,2}

Table 1. Characteristics of an ideal gas insufflation that meets CO₂,^{1,2}

The properties of an ideal gas insufflation
• colorless   • antiknock   • fireproof   • limited feature resorption   • limited physiological effects on the body after absorption   • rapidly excreted from the body after absorption   • does not support the occurrence of burns   • limited physiological effects in the case of intravascular embolization   • highly soluble in blood

It is a known fact that greater intra-abdominal pressure during laparoscopic procedures provides better and improved exposure of the operating field and allows the surgeon to perform easier operation. It is also known that the insufflation gas in the body cavity above certain value leads to a change in the body, such as disorders of homeostasis, disorders of respiratory function of the lung, and the resulting disturbance of blood gas values and the occurrence of acidosis.¹ Furthermore, increased intrabdominal pressure may cause the transient disturbances of liver^{1,2} function, kidney^{1,2,3} and a series of hemodynamic changes in organism.¹ Momentary pathophysiological changes that occur in the body during laparoscopy with standard insufflation pressure are shown in Table 2.

Table 2. The pathophysiological effects of increased intra-abdominal pressure on organism¹

Effects of increased intra-abdominal pressure on the body
• Cardiovascular and hemodynamic disorders   • Respiratory disorders   • Decreased blood flow through splanchnic blood vessels, liver and kidneys   • Increase venous stasis in the lower extremities   • Increased intracranial pressure

In patients with severe cardiorespiratory disease, patients with tumors, traumatized patients and patients with already impaired renal function and liver, there is a high risk in the application of standard methods with standard laparoscopy with intra-abdominal pressure of 14 mm / Hg due to the possible emergence of numerous complications,^{1,4-8,14} Overview of basic possible complications caused by CO₂ pneumoperitoneum pressure laparoscopy in abdominal surgery can be seen in Table 3.

Table 3. Transient disturbances caused by increased IAP during laparoscopy in abdominal surgery.

TYPE STANDARD disorders caused by PNP (12-15 mm / Hg)
Cardiovascular and hemodynamic disorders
• Decreased venous flow to the heart   • Increased consumption of O₂ level   • infarction   • The reduction of cardiac output   • The increase in systemic vascular resistance   • The increase in vascular resistance in the lung
Respiratory disorders
• The increase in Pa CO₂   • Decreased arterial pH (acidosis)   • Decreased functional residual capacity   • Increase anatomic dead space   • PaO₂ unchanged
Hypoperfusion abdominal organs
• Hepatoporalni effects   ◦ the transient hypoperfusion hepatocytes   ◦ the increase in aminotransferases   ◦ the reduced flow through the portal vein and a, hepatic   • Splanchnic effects   ◦ Reduced airflow through the stomach and other organs   • Renal effects   ◦ reduction of renal blood flow   ◦ the lower glomerular filtration rate   • Increased venous thrombosis in the lower extremities and abdomen
Increased intracranial pressure

Due to all the abovementioned, a way to make an adequate exploration of abdominal laparoscopic procedure and to avoid the possible complications and adverse effects of pneumoperitoneum on the whole organism and intra-abdominal organs was required. It was necessary to reduce or eliminate the negative effects of insufflated gas in the stomach in order to avoid possible complications listed. Hence, the alternative techniques in laparoscopy, which can reduce the negative effects of CO₂ pneumoperitoneum, reduce risks for patients and istoveremeno raise the abdominal wall and allow the surgeon to perform smooth operation, were created.

Alternative techniques can be divided into three groups:

- Laparoscopy using pneumoperitoneum intraabdominal low pressure (up to 8 mm / Hg);^{1,3,7-8}
- Laparoscopy using retractors of abdominal wall and limited pneumoperitoneum (up to 5 mm / Hg);⁹

- Laparoscopy without the use of gas (gasless laparoscopy; raising the abdominal wall retractor only).^{10,11}

These techniques represent a good alternative for the application of laparoscopy in cases where there are high risks for the use of a standard pneumoperitoneum with the values of pressure in the abdomen from 12-14 mm / Hg. Randomized prospective clinical studies have shown that the gasless laparoscopy with limited insufflation using retractors, where there are almost no negative effects of pneumoperitoneum on organism is the most economical.⁹⁻¹⁵

Laparoscopy with low pressure intrabdominalnim

In cases when it comes to difficult patients with impaired cardiorespiratory reserve, laparoscopic surgery can be done at the IAP of 8 mm / Hg. Since laparoscopic cholecystectomy is considered to be the gold standard in chronic calculus cholecystitis, this procedure can be done by applying low pressure pneumoperitoneum, and in patients with heart comorbidity. Of course, it is necessary to raise the insufflation pressure in the abdomen to 15 mm / Hg at first, in the process of establishing pneumoperitoneum, and setting the primary and secondary trocar. Taking into consideration that it takes a very short time, this initial high IAP usually does not have major consequences for the patients.^{7,9-14,15}

There are many benefits of insufflation pressure not exceeding 8 mm / Hg. At this pressure, there are no disorders in the body caused by pneumoperitoneum of 14 mm / Hg. Changes in liver function, kidney function and respiratory changes are almost non-existent in patients done by low pressure, especially when it comes to short-term laparoscopic surgical procedures and when it comes to ASA I or ASA II patients.^{7,8,15} What may represent less difficulty in dealing with this low pressure is the fact that the free space of the abdominal cavity is decreased, which can make it more difficult for the surgeon during the laparoscopic surgery. If it is a case of less experienced surgeon or complex laparoscopic surgery, sometimes it is not possible to perform the surgery at this pressure in abdomen. In that case, it is advisable to apply some of the alternative techniques, gasless laparoscopy or open, conventional method.

It has also been established that laparoscopy with low pressure in the abdomen causes less postoperative pain, and less frequent pain in the right shoulder and avoids the side effects of increased insufflation pressure on the liver. Also, when it comes to an experienced surgeon, the safety of operation with low insufflation pressure is no less than when working with standard pneumoperitoneum. There is no evidence of differences in the number of complications, mortality and frequency conversion between working with low and high insufflation pressure. It has also been proved

that the method of laparoscopic cholecystectomy in low insufflation pressure (8 mm / Hg) does not lead to reduced blood flow through the liver and other abdominal organs which occurs in standard pneumoperitoneum of 14 mm / Hg.^{7,8-13,17}

Distribution of mean values of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) during laparoscopic cholecystectomy in insufflation pressure of 8 and 14 mm / Hg is shown in Chart 1.⁷

Chart 1. Distribution of mean values of ALT and AST during laparoscopic cholecystectomy in insufflation pressure of 8 and 14 mm / Hg (Hasukić, 2005)

Low insufflation pressure in the abdomen during laparoscopy is beneficial for the patients with laparoscopic procedures and its routine use in elderly patients or patients with severe cardiorespiratory diseases should be common practice. Routine usage of low insufflation pressure in patients with severe hemodynamic and cardiorespiratory disorders are recommended by many surgeons.^{2,3,8,13-15-17} Regardless the numerous studies that favor laparoscopy with low insufflation pressure, most surgeons do not perform it routinely, but selectively, according to the needs and condition of the patient, which is probably the most appropriate. Cooperation between surgeons and anesthesiologists in terms of determining the modes and values of intra-abdominal pressure during laparoscopy is very important.

Laparoscopy using retractors and limited pneumoperitoneum

Simultaneous use of retractors (erector) of the abdominal wall and limited pneumoperitoneum to IAP values of 3-4 mm / Hg is a very favorable technique that does not have some influence on the organism as a standard pneumoperitoneum as the limited insufflation gas allows the surgeon to perform the operation more easily. The first techniques of the usage of retractors of abdominal wall implied partial insufflation of the abdominal cavity in order to achieve better overview.¹⁸ The list and

history of these instruments are presented in Table 4.

Table 4. History of different types of retractors abdominal wall that require limited and insufflation gas

Types of retractors the abdominal wall that require limited and insufflation gas

- SEMM 1991 - ACE WISAP- T-shape
- GAZIERLY 1991 MODEL-1-T-shape
- KITANO 1992.- U form- additional exposure
- BANTING 1993- Loop form - raising leagues. falciform
- ARAKI 1993- KIRSCHNER wire
- DRAGOJEVIĆ 1994- spreading trocar
- SCHALLER 1994- PCA- compression of viscera

T-shape erector of abdominal wall is designed to be inserted into the abdomen through a trocar with a slight lifting of the anterior abdominal wall, after which the abdomen inflates gas of up to 8 mm / Hg.¹⁹ U-shaped retractor is designed to require limited insufflation gas during its setting (up to 4 mm / Hg). After installation, there is no need for gas because it is possible to achieve exposure of the operative field with the reactor only.^{9,10,18,19} Elevation of leagues falciform is performed with specially made polyethylene bent trocar. Various modifications of the retractors were made with the aim of raising the abdominal wall by lifting leagues falciform. This method is applied along with the pneumoperitoneum low pressure.^{9,18,19} Scheme of different types of retractors abdominal wall that require limited and insufflation gas can be seen in Figure 1.

Figure 1. Different types of retractors of abdominal wall which demand a limited gas insufflation

Gasless laparoscopy

Elevation of the abdominal wall without using any gas and with the help of special retractors is defined as gasless laparoscopy.^{18,20,21} This method was first applied by Nagai in 1991 during laparoscopic holicistectomy.²⁰ Types of retractors of the abdominal wall that does not require pneumoperitoneum are displayed in Table 5.

Table 5. Types of retractors the anterior abdominal wall that does not require pneumoperitoneum

Types of retractors the anterior abdominal wall that does not require pneumoperitoneum

- Naga 1991 - subcutaneously placed needle
- HASHIMOTO 1993- double wire
- CHIN and MOLL 1993- "laparolift" system
- Conventional retractors

In the method promoted by Nagai, it is a common practice to use Kirschner's wires that are placed subcutaneously in the appropriate places of anterior abdominal wall. The wires are attached to a special L retractor which is attached to the operating table.²⁰ Modification of this method of raising the anterior abdominal wall was done by Hashimoto in 1993 who used two 30 cm-long Kirschner's wires attached again to the special retractor that was attached to the operating table.²¹ Chin and Moll were the first to announce and introduce the usage of the technique of flat-raising abdominal wall.²² Original system is standardized, produced and is available under the name LAPAROLIFT. Conventional retractors of different manufacturers are also in use during gasless laparoscopy and they require special minor incision upon the setting up the. They may occur in different shapes. Schematic outline of gasless laparoscopy is displayed in Figure 2.

Figure 2. Scheme gasless laparoscopy with the help of LAPAROLIFT

The technique of setting LAPAROLIFT system in gasless laparoscopy

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- Reinforce the retractor to the side of the operating table before cleaning the operative field.
  - Standard preoperatively cleaning of the abdomen, and before covering the same, it is necessary to enfold the retractor in transparent plastic bag.
  - The standard approach for almost all intra-abdominal laparoscopic procedures is periumbilical area.
  - Make a small incision in the abdomen to set the retractor to lift the abdominal wall.
  - They should be different forms of reactors available retractors: array, ring, etc.
  - After entering the abdomen, open the retractor.
  - Anchor the retractor set in the belly to the LAPAROLIFT. Activate the Laparolift to the values that are equivalent to an intraabdominal pressure of 15 mm / Hg.
  - Set a laparoscope into the abdomen through an periumbilical incision
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Instruments are set through a trocar or small incision (2 cm). When it comes to this technique, laparoscopic instruments or all the longer instruments for open surgery can be used. Cleaning the operative field is possible with traditional instruments for suction and irrigation without the possibility of loss of pressure at the CO₂ pneumoperitoneum.

Potential advantages and disadvantages of gasless laparoscopy in comparison to standard laparoscopy using CO₂ with IAP of 14 mm / Hg are shown in Table 6.

Table 6. Advantages and Disadvantages of gasless laparoscopy compared to standard laparoscopy with CO₂ using the IAP of 14 mm / Hg

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Advantages and disadvantages of gasless laparoscopy

Benefits

- Prevents complications by CO₂ pneumoperitoneum in the body
- Reduces possibility for gas embolization
- No need to prevent a gas leak in the operating area
- Opens a possibility to use conventional instruments
- Secure laparoscopic methods in high-risk patients

Disadvantages

- Availability and display the operating fields are inferior to CO₂ pneumoperitoneum
  - Post-operative pain is greater than that of CO₂ pneumoperitoneum
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Gasless laparoscopy was created because of the need to prevent the negative effects of increased intra-abdominal

pressure on the body during laparoscopy, primarily in patients with comorbidity (ASA III and ASA IV). Gasless laparoscopy does not lead to significant hemodynamic changes in the body,^{23,24} there are no reports on reduced kidney nor liver function,^{25,26} the body's response to stress is lower, as well as post-operative pain and sickness.^{23,26,27} Despite these advantages, the main reason for many surgeons to put this technique in 1st place is work and adequate visualization of intra-abdominal area which often result in higher number of conversions in these methods. Although gasless laparoscopy has many advantages over the classical technique of laparoscopy with insufflation gas, its application requires an experienced and skilled surgeon, it is limited in the usage in certain small groups of patients (ASA III and ASA IV) and hence, this technique is not frequently used in practice.²⁴⁻²⁷

Conclusion

Direct and indirect effects of CO₂ pneumoperitoneum on the body during laparoscopy in abdominal surgery in high risk patients may cause certain complications or lead to the inability of laparoscopic techniques. In these cases, it is possible to use a laparoscopic technique with low IAP, which is slightly more technically demanding for the surgeon, but could be the method of choice for the patient. Laparoscopic techniques that apply lifters (ecarters) of an abdominal wall or as they are also called gasless techniques, have not become a common practice nor have they implemented in our country and in the world. The reason lies in the fact that the gasless techniques are often longer in performance, complicated for the surgeon, expensive and require additional equipment. Also, the operative field is not as comfortable as shown in the case of CO₂ pneumoperitoneum. Many surgeons find low IAP to be the most favorable technique of laparoscopy in patients with comorbidity and ASA III-V ASA status. Low insufflation pressure in the abdomen (up to 8 mm / Hg) is beneficial for patients with laparoscopic procedures and its routine usage in elderly patients or patients with severe cardiorespiratory diseases, should be a common practice.

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Laparoskopija sa niskim intrabdominalnim pritiskom i bezplinska laparoskopija u abdominalnoj hirurgiji

SAŽETAK

Poznavanjem patofiziološke osnove laparoskopskih procedura, naročito utjecaja CO₂ pneumoperitoneuma (PNP) na organizam, može se spriječiti nastanak komplikacija tokom laparoskopije. Standardni intraabdominalni pritisak (IAP), koji se koristi tokom laparoskopske hirurgije, iznosi 12-15 mm/Hg. Direktni efekat CO₂ pneumoperitoneuma je posljedica mehaničkog djelovanja samog plina i povećanja intraabdominalnog pritiska(IAP). Indirektni efekat CO₂ pneumoperitoneuma uzrokovan je absorpcijom gasa ubačenog u trbuh. Analiza objavljenih članaka koji procjenjuju efekte CO₂ pneumoperitoneuma na organizam i intraabdominalne organe doprinosi još kvalitetnijoj primjeni laparoskopske metode. Različite tehnike rada u laparoskopiji, nastale kao alternativa standardnom CO₂-pneumoperitoneumu, imaju zadatak smanjiti rizike za pacijenta sa komorbiditetom a

istovremeno podići trbušni zid i omogućiti hirurgu nesmetan rad, što je posebno važno za ASA III i ASA IV pacijente. Alternativne tehnike rada mogu se podijeliti u tri grupe: laparoskopija uz upotrebu pneumoperitoneuma sa niskim intraabdominalnim pritiskom (do 8 mm/Hg), laparoskopija uz upotrebu retraktora trbušnog zida i ograničenog pneumoperitoneuma, i laparoskopija bez upotrebe plina (bezplinska laparoskopija; podizanje trbušnog zida samo retraktorom). Nizak insuflacioni pritisak u trbuhu (do 8 mm/Hg) pogoduje pacijentima kod laparoskopskih procedura i njegova rutinska primjena kod starijih pacijenata ili pacijenata sa teškim kardiorespiratornim bolestima, trebala bi biti uobičajena praksa. Bezplinska laparoskopija je nastala zbog potrebe prevencije negativnih efekata povećanog intraabdominalnog pritiska na organizam tokom laparoskopije, prvenstveno kod pacijenata sa visokim komorbiditetom (ASA III i ASA IV). Mnogobrojne studije daju prednost laparoskopiji sa niskim insuflacionim pritiskom u odnosu na ostale tehnike rada, ali u praksi to se ne radi rutinski, nego se svaka tehnika primjenjuje selektivno, prema potrebama i stanju pacijenta, što je i najispravnije. Da bi se izbjegli neželjeni efekti CO₂ pneumoperitoneuma, što je važno kod rizičnih pacijenata, potrebno je češće operisati sa niskim IAP (6-8 mm/Hg) ili koristiti bezplinsku laparoskopiju. Ovo je posebno značajno kod operativnih zahvata koji vremenski duže traju.