

# "SECURING PNEUMOPERITONEUM DEPENDS ON THE FUNCTIONS OFFERED BY AN INSUFFLATOR"

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## 1. INTRODUCTION

Discussions about laparoscopic surgery tend to overlook the fact that pneumoperitoneum poses an often life-threatening risk. Better understanding of the physiological changes caused by pneumoperitoneum has led to new functions in the COMEG insufflator to provide safe pneumoperitoneum.

In normal conditions, the abdominal cavity is a cavity prone to negative pressure. Creating pneumoperitoneum will lead to disturbances caused by increasing intra-abdominal pressure as it becomes positive.

## 2. HEMODYNAMIC DISTURBANCES LINKED TO PNEUMOPERITONEUM

It is sometimes difficult to distinguish between the effects linked to increased intra-abdominal pressure and the effects caused by insufflated CO<sub>2</sub>, which leads to hypercapnia and respiratory acidosis.

Firstly, for up to an intra-abdominal pressure of 5 to 8 mm of mercury (Hg), there is increased venous return due to flushing splanchnic blood from the abdomen, which causes increased cardiac output.

Beyond 10 mm of mercury, the intra-abdominal pressure

reduces venous return. This effect is partially compensated by increased peripheral vascular resistance caused by hypercapnia, which increases the secretion of Noradrenaline by sympathetic stimulation. Cardiac output gradually drops beyond 12 mmHg due to increased vascular resistance, and reduced venous return. These phenomena become significant over 15 mmHg [1,2].

The study by Nagao et al. [3] showed that the risk of gas embolisms in pigs increases if the initial insufflation flow rate is too fast or if the intra-abdominal pressure is above 15 mm of mercury. The consequences are a change in heart rate, or even heart rhythm disorders.

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Prevention involves correcting possible hypovolemia before creating the pneumoperitoneum. Curarization of the patient must be complete and stable, and, if possible, performed by a syringe driver to avoid sudden increased intra-abdominal pressure by decurarization.

Pneumoperitoneum must be gradually created with an insufflation flow rate that does not exceed two liters per minute before reaching the pressure setting. This allows the patient to gradually adapt to new hemodynamic conditions. This is particularly true in elderly, cardiac or hypertensive patients where there is risk of cardiac diffusion. Accordingly, the insufflator pressure setting must never be programmed beyond 15 mmHg, at best not exceeding 12 mmHg [1,4]. It is for this reason that the COMEG insufflator has a function that insufflates at a low flow rate (2 L/min) until the pressure setting is reached. It then automatically changes to the high flow rate three seconds after having reached the pressure setting.

Furthermore, the insufflator is equipped with a system that automatically exsufflates the pneumoperitoneum in the event of excessive pressure.

### **3. THE RESPIRATORY EFFECTS OF INCREASED INTRA-ABDOMINAL PRESSURE**

Curarization reduces diaphragmatic movement, which leads to ventilation/perfusion ratio disparities in the lungs. It results in increased dead space in the lung bases [5]. This is further increased

by the Trendelenburg position [1]. Furthermore, reabsorption of CO<sub>2</sub> increases hypercapnia linked to ventilation disorders and increases acidosis.

#### **PRACTICAL CONSEQUENCES**

It is necessary to:

- Increase ventilation to compensate for the respiratory consequences of increased intra-abdominal pressure [6].
- In the event of hypercapnia, nitrous oxide, which changes the gas composition of the pneumoperitoneum and increases the risk of a gas embolism due to the low solubility of this gas [7], must be stopped,
- Remove the pneumoperitoneum if hypercapnia persists, wait for the effects to correct themselves and repeat the pneumoperitoneum with a lower pressure setting.

#### **OTHER EFFECTS OF PNEUMOPERITONEUM**

- Disposition to oliguria due to reduced renal perfusion [8],
- Reduced splanchnic circulation,
- Peripheral venous insufficiency,
- Increased intracranial pressure and intraocular pressure that contraindicates coeliosurgery in the event of angle-closure glaucoma or intracranial hypertension [9,10],
- Patient disposition to hypothermia caused by the temperature of the insufflated gas, which is often lower than 37°C. Warming the gas inside the insufflator does not change the patient's disposition to hypothermia, due to heat loss when the gas passes through the insufflation hose

and, above all, the evaporation of intra-abdominal humidity upon contact with dry gas.

One must be careful with, or even forbid, non-resorbable gas insufflation caused by the use of an argon electrocautery device, as this changes the gas composition of the pneumoperitoneum. It results in fatal injuries. In fact, even if we open the trocars whilst using these devices, the CO<sub>2</sub> is quickly replaced by argon as the insufflator stops the flow rate of CO<sub>2</sub>, since the arrival of argon maintains the continuous intra-abdominal pressure setting. We have had to gather together to study the death of a young man from a gas embolism under these circumstances [11,12]. There is also a risk with biological glue spray applicators.

### **4. INSUFFLATOR FUNCTIONS**

Schematically, the insufflator delivers a flow rate of CO<sub>2</sub> until a predefined intra-abdominal pressure is reached. The surgeon has the opportunity to program:

1. the CO<sub>2</sub> flow rate within the limits of the device's flow rate capacities
2. the intra-abdominal pressure setting beyond which the insufflator automatically halts the gas insufflation and exsufflates the excess gas.

Based on this main principle, the different manufacturers have created devices that prevent, more or less:

- the physiological risks linked to pneumoperitoneum,
- errors linked to the insufflator programming,

- and/or sudden changes to the intra-abdominal pressure linked to anaesthesia or a surgical procedure.

Two authors studied the means of increasing insufflator performance, and reducing risks for patients:

- The article by Verdaasdonk et al. [13] listed all the technical problems of the equipment used for laparoscopy. This author showed that 50% of problems found in insufflators are linked to connection errors and 50% to programming errors,
- Jacobs et al. [4] listed 25 points to improve insufflator performance.

Schematically, the insufflated volume depends on Poiseuille's law, which shows that the CO<sub>2</sub> flow is equal to the ratio of the pressure difference divided by the resistance found in the gas flow. Thus, the CO<sub>2</sub> flow is reduced proportionally:

- to the smallest radius value in the insufflation circuit at the power of 4,
- and to the length of this circuit.

Many insufflators only have one line to insufflate and measure the intra-abdominal pressure. They are therefore obliged to alternate between insufflation and measuring intra-abdominal pressure two to three times per second. It results in intermittent insufflation with spikes in pressure that temporarily exceed the pressure setting before returning to the value selected by the surgeon. The advantage is to increase the speed for establishing the pneumoperitoneum. The effects of these spikes in hypertension are

less significant if the insufflation circuit is the site of substantial resistance. It is for this reason that COMEG has made the decision to install solenoid valves that open gradually and in proportion to the measured pressure differences in its insufflator.

The COMEG insufflator is designed to meet the safety requirements thanks to several innovations:

- The detection of errors in the tubing hose connection,
- A gradual opening of the solenoid valves proportional to the measured pressure differences that, whilst allowing fast insufflation, limits excess pressure spikes in contrast to the binary opening of the valves,
- Automatic insufflation that establishes the pneumoperitoneum at a low flow rate. When the pressure setting is reached and stable, the insufflator then automatically changes to a high flow rate to compensate for the gas leakages after three seconds,
- A warning system that requires the confirmation of all pressure settings beyond 15 mmHg. Furthermore, the display is clear and avoids any possibility of programming errors that would result in a pressure setting beyond 15 mm of mercury,
- A patented system calculates and instantly displays, based on gas flow leakages, the time remaining before the end of the CO<sub>2</sub> cylinder. Furthermore, an audible alarm increases in frequency the closer it approaches the end of the CO<sub>2</sub> cylinder (patent UPMC/SOPRO). In fact, it is important that the

insufflator has an accurate alarm available to the surgeon for the duration, before changing the CO<sub>2</sub> cylinder. Thus, the surgeon is sufficiently warned in advance to anticipate a sudden drop in the pneumoperitoneum, which may occur during a difficult stage of the surgery. Apollos JR et al. showed that the majority of surgeons had been faced with this situation [14],

- The insufflator has an external exsufflation system,
- The risk of contamination of the device by liquid or peritoneal gas overflow in the event of excessive intra-abdominal pressure is prevented thanks to the possibility of inserting a filter in the tubing hose, and thanks to a y-tubing hose that allows gas exsufflation outside of the device,
- A command from the camera allows the passing and stopping of the low/high flow rate to avoid having to use a circulating nurse,
- Like its competitors, the COMEG insufflator has an internal gas heater.

## 5. WHAT MUST THE MEDICAL TEAM DO TO REDUCE THE RISKS LINKED TO PNEUMOPERITONEUM?

The surgeon must:

- Program or check the intra-abdominal pressure setting and insufflation flow rates,
- Drain the tubing hose of any air inside it before connecting it to the trocar, to avoid introducing air into the peritoneal cavity that could cause a gas embolism or post-operative pain,
- Start insufflating the pneumoperitoneum at a low flow rate

until the pressure setting is reached,

- Regularly monitor the indicators for the end of the cylinder.

The anaesthetist must:

- Compensate for possible hypovolemia,
- Ensure stable and efficient curarization,
- Monitor hypercapnia that may stop the use of nitrous oxide, or even the pneumoperitoneum.

## 6. CONCLUSION

There are several insufflators on the market that have different functions and which more or less secure the pneumoperitoneum. The choice of insufflator should factor in the risks linked to pneumoperitoneum in order to minimize them. ■

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