High Flow Insufflation for the Maintenance of the Pneumoperitoneum during Bariatric Surgery

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Key Words

Laparoscopy · Insufflation · High flow insufflator · Bariatric surgery

Summary

Minimally invasive bariatric procedures next to becoming more and more popular have established a new field of applications for carbon dioxide (CO₂) insufflators. In laparoscopic bariatric procedures, gas is used to insufflate the peritoneal cavity and increase the intra-abdominal pressure up to 15 mm Hg for optimal exposure and a suitable operating field. The increased intra-abdominal pressure during pneumoperitoneum can reduce femoral venous flow, intra-operative urine output, portal venous flow, respiratory compliance, and cardiac output. However, clinical complications related to these effects are rare. Yet, surgeons should be constantly aware that the duration of an operation is an important factor in reducing the patient's exposure to CO₂ pneumoperitoneum and its adverse effects. The optimized performance of the bariatric high flow insufflator allows reaching stable abdominal pressure conditions quicker and at a higher level than a common insufflator. Therefore, high flow insufflators offer great advantages in maintaining intra-abdominal pressure and temperature in comparison to conventional insufflators and thus enhance laparoscopic bariatric surgery by potentially reducing the operating time and the undesirable effects of CO₂ pneumoperitoneum.

Introduction

Surgical therapy is currently the only effective method of sustained weight loss for the treatment of morbid obesity and its related comorbidities. Since 1994, when Wittgrove et al. [1] reported the first cases of laparoscopic gastric bypass, the field of laparoscopic bariatric

surgery has evolved into several types of procedures to promote weight loss. Laparoscopic surgery is performed through the creation of a workspace between the abdominal wall and the internal organs, most commonly by insufflation of carbon dioxide (CO₂) to a level of positive intra-abdominal pressure tolerated by the patient. In laparoscopic bariatric procedures, gas is used to insufflate the peritoneal cavity and increase the intra-abdominal pressure up to 15 mm Hg for optimal exposure and an efficient operating field. In this short review, the role of high flow insufflation in the maintenance of the pneumoperitoneum during bariatric surgery is assessed.

Effects of the Pneumoperitoneum

Laparoscopic bariatric surgery has gained clinical acceptance as a definitive method for the treatment of morbid obesity. The main advantages of laparoscopic surgery are a faster recovery, less post-operative pain, shorter hospitalisation, and better aesthetic results. Pneumoperitoneum, using CO₂ as an insufflating agent, became firmly established only after the development of the automated peritoneal insufflator by Kurt Semm in the 1960s [2]. CO₂ is the most common insufflating agent for establishing the pneumoperitoneum at laparoscopy as it is easily obtained, chemically stable, non-flammable, highly soluble in blood and tissue, and rapidly absorbed from the peritoneal cavity, with metabolic end products easily exhaled through the pulmonary alveoli.

Laparoscopy produces similar physiologic changes in both morbidly obese and non-obese patients. Absorption of CO₂ during pneumoperitoneum can lead to an increase in PaCO₂ levels, however, hypercarbia is commonly avoided with appropriate ventilatory changes. Absorption of CO₂ also alters the acid-base balance and the increase in CO₂ excretion load. Compared with baseline values, the increased intra-abdominal pressure during pneumoperitoneum can reduce femoral venous flow, intra-operative urine out-

put, portal venous flow, respiratory compliance, and cardiac output [3]. Additionally, changes in body position, especially the head-up tilt position (reverse Trendelenburg position), may intensify the negative effects of a pneumoperitoneum by further decreasing venous return, cardiac preload, and output. Although significant hemodynamic changes have been associated with the pneumoperitoneum, most of the studies about CO₂ pneumoperitoneum have demonstrated that organ dysfunctions generally return to normal after desufflation at the end of the operation in a very short time, and that clinical complications related to these effects are rare [4–6]. Yet, surgeons should be constantly aware that the duration of an operation is an important factor in reducing the patient's exposure to CO₂ pneumoperitoneum and its adverse consequences. Furthermore, studies have shown that the negative effects on haemodynamic parameters are diminished if the pressure level is well-controlled [7, 8].

Prolonged insufflation with CO₂ is also associated with a reduction in body core temperature. Laparoscopic hypothermia and possible prevention methods have been controversially discussed within recent years. Since a decrease of intra-operative body temperature is related to a variety of complications, maintaining the patient's body temperature is considered standard of care. Nguyen et al. [9] demonstrated that the heated humidified gas, when used in conjunction with an external warm blanket, minimised the reduction of intra-abdominal temperature but did not alter core temperature or reduce postoperative pain. However, a recent meta-analysis [10] concerning the effect of warm humidified insufflation on pain after laparoscopy demonstrated a reduction in postoperative pain with warm humidified gas in major laparoscopic surgery. Moreover, it has been shown that the use of warmed CO₂ insufflation during laparoscopic gastric bypass had a significant impact on the ergonomics of the operating room, allowing more time for the personnel and the surgeons to concentrate on the surgery, with decreased total operating time and decreased cost [11]. Furthermore, measurements of the CO₂ gas temperature of insufflators with internal gas heating versus those without, at increasing flow rates measured at insufflation hose end, showed a flow-dependent increased gas temperature at the insufflator exit [12].

Bariatric Insufflator

The bariatric insufflator is designed to fill and distend the peritoneal cavity for laparoscopic surgery in morbidly obese patients. Such an advanced insufflator should establish the pneumoperitoneum in a short time and be able to maintain the desired pressure in order to create optimal conditions. The ideal insufflator should utilize the over-pressure principle (for achieving the preset pressure, insufflation peaks are above the desired pressure) by using real-time pressure monitoring. This is achieved by using a second pipe, which is used for pressure measurement only and which is connected to a free trocar. Hence, the insufflator is able to pump CO₂ into the abdominal cavity continuously while constantly measuring the intra-abdominal pressure. This is a key function of an ef-

Table 1. Comparison of the performance of the 2 devices using different ways of insufflation

	Insufflators	
	Pneumo Sure™	conventional
<i>Veres needle</i>		
Preset pressure reached	yes	no
Time to reach pressure	31 s	43 s (12 mm Hg)
Leakage compensation	yes	yes (at 12 mm Hg)
Maximum flow	6 l/min	5 l/min
<i>5 mm trocar</i>		
Preset pressure reached	yes	yes
Time to reach pressure	12 s	15 s
Leakage compensation	yes	yes
Maximum flow	12 l/min	10 l/min
<i>10 mm trocar</i>		
Preset pressure reached	yes ^a	yes ^a
Time to reach pressure	6 s	7 s
Leakage compensation	yes (21 l/min)	yes (15 l/min)
Maximum flow	23 l/min	21 l/min

^a Decreases during leakage to 10 mm Hg.

ficient bariatric insufflator since rapid gas loss can occur during anti-obesity surgery due to the heavy abdominal wall and the multiple surgical manipulations required. The bariatric high flow insufflator (Pneumo Sure™ High Flow Insufflator; Stryker, Selzach, Switzerland) delivers rapid insufflation of large volumes in order to fill and maintain the abdominal volume, even in cases of gas loss (leakages) due to frequent instrument changes or when up to 7 trocars are used. This insufflator maintains the preset pressure by allowing warm gas to flow up to a maximum of 45 l/min.

In bench tests, the 'Bariatric mode' of the Pneumo Sure High Flow Insufflator was evaluated regarding performance in the continuous mode. The aim of the test was to assess the flow and pressure regulation of the bariatric mode in terms of efficacy when performing endoscopic surgery in massively obese patients and to compare it with a common 'normal' insufflator. The tests were performed on a dummy abdomen with a volume of 2,200 ml CO₂ when filled to 15 mm Hg.

The high flow insufflator was compared with a common one regarding leakage compensation and maintenance of preset pressure, using a high flow Veres needle, a 5 mm trocar, and a 10 mm trocar (table 1).

The insufflation tube was connected to the instruments via luer lock. When using the Veres needle at a leakage rate of 3 l/min and a preset pressure of 15 mm Hg, the Pneumo Sure insufflator compensated the leakage and reached the preset pressure of 15 mm Hg, whereas the common insufflator compensated the leakage but only reached an actual pressure of 12 mm Hg. Moreover, the time required by the high flow insufflator to reach the preset pressure of 15 mm Hg was approximately 30% less compared to the normal insufflator, which only reached a pressure of 12 mm Hg (fig. 1). With the 5 mm trocar, a preset pressure of 15 mm Hg, and a leakage rate of 3 l/min, both insufflators compensated the leakage, however, the high flow insufflator reached the preset pressure 20%

Fig. 1. High flow insufflator flow and pressure graph: Veres needle + leakage. — F114 (pressure); - - - F114 (flow); . . . F114 (leakage).

Fig. 2. High flow insufflator flow and pressure graph: 5 mm trocar + leakage. — F114 (pressure); - - - F114 (flow); . . . F114 (leakage).

Fig. 3. High flow insufflator flow and pressure graph: 10 mm trocar + leakage. — F114 (pressure); - - - F114 (flow); . . . F114 (leakage).

faster (fig. 2). The 10 mm trocar was used with a preset pressure of 15 mm Hg and a leakage rate of 21 l/min after 21 s when the high flow insufflator was tested, and 15 l/min for the common one. Both insufflators reached the preset pressure of 15 mm Hg. However, Pneumo Sure compensated the leakage of 21 l/min at a pressure of 10 mm Hg, whereas the normal insufflator compensated the leakage of 15 l/min at a pressure of 7 mm Hg. In addition, the insufflation time of the high flow insufflator to reach the preset pressure was 15% faster compared to the normal one (fig. 3).

The optimised performance of the bariatric insufflator allows reaching stable abdominal pressure conditions quicker and at a higher level than a common insufflator. The Pneumo SureTM insufflator produces a significantly higher performance and can compensate even high leakages, which often occur during bariatric pro-

cedures, e.g. when using many trocars or when carrying out frequent instrument changes. Due to an increased flow performance, insufflation time is decreased compared to common insufflators. Therefore, high flow insufflators offer great advantages in maintaining intra-abdominal pressure and temperature in comparison to conventional insufflators and thus enhance laparoscopic bariatric surgery by potentially reducing both operating time and undesirable effects of CO₂ pneumoperitoneum.

Disclosure

The authors declared no conflict of interest.

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