Humidification in Laparoscopy

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Guniz Meyanci Koksal and Ulgen Zengin

12.1 Brief Discussion

1. Today, laparoscopic procedures are widely preferred with an increasing rate for they are more cosmetic and surgical stress is lower when compared with conventional techniques.
2. The cold (−21 °C) and dry (0%) CO_2 used in laparoscopic surgery causes an increase in the postoperative pain and need for analgesics and a decrease both in preoperative and postoperative patient comfort accompanied by morphological and metabolic changes in the peritoneum.
3. Cold and dry CO_2 causes the patient to be hypothermic, and external heating is insufficient in preventing hypothermia.
4. Warming and humidification of CO_2 is the order of the day although some studies suggest that warming and humidification does not prevent the effect of cold and dry gas.
5. The side effects of cold and dry CO_2 must be prevented. New prospective, blind clinical studies must be carried on with different techniques of warming-humidification and different temperatures and humidification concentrations using constant wide patient groups by skilled surgical and anesthesia teams.

Laparoscopic interventions were firstly described in 1987 as minimally invasive techniques which were widely used especially in abdominal surgery. Laparoscopy

G. M. Koksal (✉)
Department of Anesthesiology and Reanimation, Cerrahpasa Medical School, Istanbul Cerrahpasa University, İstanbul, Turkey

U. Zengin
Department of Anaesthesiology and Reanimation, Marmara University Medical Faculty, İstanbul, Turkey

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is used not only for the abdomen but also for invasive procedures to be performed in cavities such as the thorax and pelvis [1].

In abdominal surgery, pneumoperitoneum is created by insufflation of gas into the abdominal cavity through the peritoneum. The insufflated gas is frequently carbon dioxide (CO_2) gas. Pneumoperitoneum causes an increase in intra-abdominal pressure. The increase in pressure impairs the perfusion of the intra-abdominal organs, especially the mesenteric region and kidneys. Moreover, the cardiac output decreases, which pushes the diaphragm up, causing atelectasis in the basal parts of the lungs, and the ventilation perfusion ratio is also impaired. Also, moderate hypoxia and hypercarbia are observed, and urine output is decreased (<0.5 mL/kg) [2].

However, since it is a minimally invasive procedure, the incision size and pain are less, and early mobilization is possible. The patient's fluid loss and infection rates are also reduced.

The CO_2 gas used during peritoneal insufflation is a dry and cold gas. For every 50 L of gas insufflation, the body temperature drops by 0.3 °C. CO_2 gas is stored as liquid in cylinders at an average of −90 °C, its temperature is between −19 °C and, −21 °C, and its relative humidity is 0. The temperature of the peritoneal cavity is 36 °C, and the relative humidity is virtually 100%. The constant presence of CO_2 gas in the peritoneal cavity in the peritoneal mesothelium causes morphological and biochemical damage. In fact, using heated and humidified gas will prevent hypoxemia, reduce pain, and decrease the amount of analgesic used in the postoperative period. Even just warming the patient will have a positive effect and results in the prevention of hypothermia. Even insufflation of heated-non-humidified CO_2 gas has been demonstrated to reduce humoral inflammation in the peritoneum [3, 4].

Hypothermia causes significant perioperative morbidity, and it is important to the anesthesiologists. We have noted in our daily practice that prolonged abdominal laparoscopy is responsible for a significant drop in core body temperature. This results from the combination of specific heat losses, particularly via convection and evaporation, leading to less energy loss from the body due to the insufflated gas, and nonspecific heat losses caused by the imbalance of thermoregulatory mechanisms during general anesthesia [5]. The warm abdomen and the organs therein make a large internal surface area for heat exchange, and because gas is constantly circulating and being renewed, there is a significant energy transfer from the patient to the intraperitoneal gas as the gas is warmed [6]. The focus of many studies was to evaluate in a prospective, randomized, controlled study the postoperative outcomes of pain and narcotic use with patient having different kinds of procedures comparing conventional dry-cold, dry-warmed, and humidified-warmed gas [6].

Pneumoperitoneum damages the mesothelial cells of the peritoneum. Mesothelial cells contain an average of 230 microvilli per 10 μm^2. These microvilli allow the exchange of molecules by providing tissue mobility between the peritoneum and organs. CO_2 gas causes bulging, delaminization, and loss of villi and death in mesothelial cells. The effect of CO_2 gas also increases in the organism where inflammatory markers increase with a rise in peritoneal pressure. Especially in patients who will be scheduled for laparoscopic cancer surgery, mesothelial tissue defect and inflammatory process should be minimal in order to prevent the spread of cancerous cells [7].

In laparoscopic surgery, low peritoneal pressure (>12 mmHg), normothermia, and heating and humidification of CO_2 gas will reduce many of the mentioned processes, although these cannot be completely prevented. The vavless or CO_2 recirculating systems specifically used in robotic surgery, effective methods for reducing systemic and localized inflammation. Temperature control is also important in terms of reducing surgical infections [8].

Devices such as HumiGard and AirSeal (iFS, USA) are used to humidify and heat the CO_2 gas used during insufflation. The tube system of these devices is disposable and expensive. Fisher & Paykel's systems can be preferred, which heat the CO_2 gas up to 37 °C and humidify 98%. The use of these systems, especially in elderly patients, will result in a more stable hemodynamics and decrease in lactic acid level and shorten the recovery [9].

Savel et al. [10] performed a randomized double-blind, prospective, controlled clinical trial of 30 patients undergoing laparoscopic Roux-en-Y gastric bypass. Patients received postoperative analgesia from morphine, delivered via a patient-controlled analgesia pump, and pain scores and amount of morphine were measured postoperatively. Their trial was unable to provide evidence of any significant reduction in postoperative pain as measured by either morphine requirements or pain scores with the use of warmed-humidified CO_2. They were able to demonstrate a statistically significant increase in end-of-case temperature with the use of this device, but this result is not clinically significant.

Mouton et al. [11] advocated that the use of humidified insufflation gas reduces postoperative pain following laparoscopic cholecystectomy, but the heat-preserving effect of humidified gas insufflation is not significant.

Peng et al. [12] suggest that heated (37 °C)-humidified (95% relative humidity) insufflation results in significantly less hypothermia, less peritoneal damage, and decreased adhesion formation as compared with cold-dry CO_2 insufflation.

12.2 Conclusion

It has been proved that the use of cold and dry CO_2 in laparoscopic surgery causes an increase in the postoperative pain, hypothermia, acidosis in the peritoneum, and a decrease both in preoperative and postoperative patient comfort. The loss of heat during perioperative period causing hypothermia is an important concern for the anesthesiologists and intensivists. Hypothermia not only causes some metabolic changes but also prolongs the recovery from the anesthesia, resulting in the increased use of supplies and drugs that might lead to a need to ICU. All of these will result in increased hospital stay, morbidity, and cost. To avoid this, we try to keep the patients' temperature between physiological limits by warming out patients perioperatively. In laparoscopic surgery, it is not possible to keep the patients' temperature in normal values with external heating for the surgeons prefer to use cold-dry CO_2. Although many studies were made in the past decade on the warming and humidification of CO_2, there are still two different opinions, one supporting the warming and humidification and the other against it. The most important factor on these two

different opinions is the discrepancy between the protocols of the studies. The warming temperature and the rate of humidification, the patient groups, and the type and the duration of the operations differ in study groups. It is more appropriate to standardize the patient groups and warming and humidification rate of the gas, in prospective, blind clinical trials. In these studies, different warming levels and different concentrations of humidification that are suitable for human physiology must be used. As commonly accepted, the results of the animal trials are not thoroughly concordant with the human studies. Especially in studies where pain and the amount of analgesic used are evaluated, using animal model may not be correct. This discordance is more evident in small animals like rats. It is also an issue who the surgeon doing the laparoscopic surgery is. The use of laparoscopic surgery has increased dramatically in the last decade because of cosmetic concerns and its lower surgical stress. It is essential that the surgical team must be experienced in the procedure and must give a proper position to the patient and the gas must be thoroughly emptied. All of these factors affect the postoperative waking from the anesthesia, pain, amount of analgesic used, and the hemodynamics of the patient. Hence, the study protocols dealing with the warming and humidification of CO_2 in humans must be accomplished by skilled teams.

In the future studies, the techniques of warming and humidification must also be evaluated. Different techniques will surely affect the results of the studies. Nowadays, different techniques such as HME Booster, modified Aeroneb, and Pall system are worked on, and still no distinction has been shown on any technique.

Wang et al. [9] introduced in a pig model that the acidosis created on the peritoneum by the CO_2 gas in laparoscopy increases the implantation of tumor cells and the warming and humidification of CO_2 or buffering with bicarbonate does not decrease this impact. Therefore, a detailed study is needed on the consequences of CO_2 insufflations in laparoscopic surgery in oncologic patients.

As a result, although there are negatory concerns on the warming and humidification of CO_2 used – to raise the abdominal wall – during the laparoscopic surgery, wide series of human studies in different physiological temperatures and humidification concentrations are needed to eliminate the side effects of cold and dry gas.

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