Editorial

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Hypothermia

A potential risk of CO_2 insufflation?

Although laparoscopy with CO_2 insufflation has been safely and effectively used for twenty-five to thirty years, some basic pathophysiology questions regarding its use have not been answered—especially the effects CO_2 insufflation has on core body temperature and postoperative pain. In this issue of *Surgical Endoscopy: Ultrasound and Interventional Techniques*, Bessell et al. [1] and Mouton et al. [2] report on a laboratory model and a clinical trial that address these issues. This model of investigation should be commended for identifying clinical problems and initially collecting and evaluating data in the laboratory and then applying this information in a clinical randomized prospective trial.

Even in open surgical operations, core temperature hypothermia has been recognized as causing negative effects on body functions, such as an increased susceptibility to dermal infection, altered levels of consciousness, development of hypokalemia, increased cardiac output, thrombocytopenia, depletion of clotting factors leading to bleeding disorders, and the production of negative nitrogen balance. In open surgery, the use of space blankets, irrigation of the abdominal cavity with warm saline, and raising the operating room temperature are important factors in preventing or correcting hypothermia. In one open surgery study [3], postoperative mortality increased from 4% to 24% when hypothermia lasted longer than two hours. If complications from hypothermia develop, the morbidity, mortality, and length and cost of hospitalization will increase. Therefore, identifying the effect of CO_2 on core body temperature and pain is important.

In the first study, performed by Bessell et al. [1] using a pig model in a randomized controlled study, changes in core temperature were evaluated over a three hour operative period using high flow carbon dioxide insufflation. Each animal was anesthetized and studied on three separate occasions under standardized conditions comparing insufflation with no gas, cool carbon dioxide, and heated humidified carbon dioxide. It was observed that after insufflation with cool carbon dioxide, the core temperature dropped by 1.8°C as compared with only a 0.6°C decrease experienced by control animals and those insufflated with heated humidified gas ($p < 0.01$). They also determined that a 1.5°C lower temperature would occur due to water evaporation alone in pigs insufflated with the cool dry carbon dioxide. Their conclusion was that the majority of heat lost during laparoscopic insufflation was due to water evaporation in hypothermia induced by laparoscopy and that this effect could be prevented with heated humidified gas insufflation. It has also been reported that core body temperature can decrease 0.3°C for each 50 liters of CO_2 used for insufflation [4]. Therefore, procedures requiring more than two to three hours of insufflation are more likely to develop hypothermic risk factors.

In the second study from the same laboratory, Mouton et al. [2] reported a prospective randomized trial assessing 40 patients undergoing laparoscopic cholecystectomy in which 20 patients received heated (34–37°C) humidified (88%) CO_2 insufflation gas and were compared to 20 patients receiving cool (21–25°C) CO_2 insufflation with a humidity of 0–5%. Two outcome measurements were assessed including core body temperature and postoperative pain. They noted that there were no adverse effects from the heated humidification of the CO_2 gas. Pain was assessed by a visual analog pain score six hours postoperatively and on postoperative days 1, 2, 3, and 10. The operative procedure was laparoscopic cholecystectomy and the mean duration of pneumoperitoneum was 40 minutes in the humidified group and 48.3 minutes in the control group. They observed that the decrease in mean core body temperature during pneumoperitoneum was not significantly different between the groups (0.25°C in the humidified group and 0.3°C in the control group). However, the short duration of this procedure most likely accounted for the insignificant change, but a longer pneumoperitoneum time as in advanced laparoscopy may significantly alter the core body temperature, as was noted in the study by Bessell et al. [1]. The mean postoperative pain requirement for patients receiving humidified gas was 50% less than the control group but these numbers were small and not statistically significant. However, this trend toward a decreased pain requirement was also noted postoperatively at six hours, and on the first, second, third, and tenth day. Although the length of hospitalization was not different between the two groups, it was also observed that patients receiving heated humidified CO_2 returned to normal activity in 5.9 days as compared to 10.9 days in the control group, and the return to work was 9.9 days in the humidified group and 14.7 days in the control group. Whether this improved return to normal activity was the result of less pain is suggested by this study, but it needs to be further evaluated.

These data identify several important benefits of the use of heated humidified CO_2 as the insufflation gas. It appears that heated humidified gas is a key factor in preventing heat loss as opposed to dry heated CO_2, since there is an expected temperature decrease from the heat required for water evaporation, which Bessell et al. [1] noted was similar to control animals and those receiving cool dry gas. However, only heated CO_2 insufflators without humidification are commercially available. The clinical study by Mouton et al. [2] was of short duration (40–45 minutes), and hypothermia probably would not occur. Therefore, clinical trials comparing heated humidified CO_2 and cool CO_2 insufflation are needed in procedures that require abdominal insufflation times greater than two to three hours. Bleeding complications resulting from hypothermia has potential detrimental effects and profuse bleeding may obscure the operative field and necessitate conversion to an open procedure. Intraabdominal and core temperature equilibration may occur when there is minimal CO_2 loss, as may occur when there is little movement of instruments in and out of the ports. However, in most advanced procedures, instrument exchange is frequent and carbon dioxide loss is common and infusion with cool carbon dioxide into the intraperitoneal cavity frequently occurs, thus increasing the potential for heat loss. However, recording the number of instrument exchanges in a procedure must be considered in future studies.

Another question often raised after laparoscopic procedures is why there is more pain than expected with small incisions especially in the immediate postoperative period. Suggested mechanisms for this pain have included ultracellular trauma to the peritoneum caused by circulating dry carbon dioxide gas, neuropraxia of the phrenic nerve by dissolved carbon dioxide and the formation of carbonic acid that lowers the pH of the peritoneum peritoneal distension, electrothermal trauma to the peritoneum, irritation from undrained fluid collections, and retained intraperitoneal gas. Although the postoperative pain problem is often multifactorial, it appears that using humidified heated carbon dioxide can reduce this pain. The additional cost of a humidifier to the insufflating tubing should be minimal and if the benefits of decreased pain and possibly earlier return to normal activities are improved with its use, this small additional cost to the laparoscopic equipment hospital charge may have significant societal cost benefits. However, these issues need to be confirmed in a larger study population with longer pneumoperitoneum insufflation times.

Another potential benefit of heated humidified carbon dioxide would be less fogging of the laparoscope lens, thus minimizing laparoscope removal and reheating that often disrupts the flow of the operation and increases operative time. In my institution, the laparoscope is heated in a water bath to 120°F prior to its insertion into the abdomen, which does minimize fogging. Heated humidified CO_2 maintains intraabdominal temperature and thus antifog solutions on the laparoscope lens may not be necessary.

Therefore, hypothermia should be considered in all procedures requiring more than two to three hours of abdominal insufflation. Corrective measures, such as using heated body space blankets and irrigating the abdominal cavity with warm saline, may be necessary, as well as maintaining a warmer environment in the operating room. As laparoscopic procedure length increases, recognition and prevention of hypothermia will become more important.

References

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