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Laparoscopic Hypothermia

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ABSTRACT

Operative laparoscopy is experiencing an increase in its use and indications. This expansion exposes patients to increased operating time, larger volumes of carbon dioxide for maintenance of a pneumoperitoneum, and higher gas flow rates for intraperitoneal delivery. Patients with medical complications, advancing age, and potentially contaminated procedures are now considered acceptable candidates for operative endoscopic techniques via laparoscopy. A previously observed but unquantified amount of hypothermia was measured and evaluated by changes in core temperature after known quantities of carbon dioxide were delivered intra-abdominally over measured periods of time and with controlled flow rates. A decrease of 0.3°C in the core temperature was observed for each 50 L of carbon dioxide delivered.

INTRODUCTION

THE USE OF CARBON DIOXIDE for creation of a pneumoperitoneum at laparoscopy exposes patients to many potential hazards.[1,2] Operative laparoscopy require extensive, expert, and prolonged surgical procedures. This places the patient at heightened risk for complications. These risks are not inherent only to the particular specific surgical procedure, but include factors that are common to all laparoscopic surgeries, the creation of a pneumoperitoneum. This has led to the identification of hazards related to the process and maintenance of a safe, physiologic intra-abdominal endoscopic environment. In the interest of patient safety and to reduce complications and consequences, recognition and reduction of these dangers is necessary. Hypothermia during surgery as a result of cold ambient operating room temperature is a well-recognized complication.[3,4] Accidental hypothermia (cold exposure) and specific operative hypothermic techniques (cardiovascular and neurosurgical) have also been reported.[3,5] Parenthetical observation of hypothermia during laparoscopy has been noted but was not quantified.[6] This report evaluates, describes, and quantitates the increased hypothermic risk associated with carbon dioxide pneumoperitoneum.

MATERIALS AND METHODS

A study was conducted to evaluate the intra-abdominal and core temperature in patients undergoing laparoscopy with carbon dioxide pneumoperitoneum. All patients in the study group received a detailed description of the proposed placement of a temperature-sensing device to be used during the surgical

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procedure. Data were obtained by observing and recording temperature changes at timed intervals of carbon dioxide insufflation and after measured quantities of carbon dioxide instillation. Forty patients having laparoscopy for tubal sterilization, evaluation and treatment of pelvic pain, endometriosis, and adhesions comprised the study group. All procedures were performed and accomplished without the use of a thermal device (cautery or laser).

Intravenous solutions were administered at room temperature. Fluid volumes infused were in the range 500–1500 cc. Intra-abdominal lavage was performed during the procedures, when appropriate, using lactated Ringer's solution at 35°C. The irrigation solution was initially warmed and kept at a constant temperature by a servo control thermal retention feedback device.

Ambient operating room temperature was recorded throughout each procedure and temperature was maintained at the level it was when the patient entered the surgical theater. Patient temperatures were obtained in a surgical holding area prior to surgery and postoperatively in the postanesthesia recovery area by tympanic assessment. Core temperature evaluations were performed and monitored throughout each procedure using a Mallinckrodt critical HiLo temperature esophageal stethoscope placed in the lower third of the esophagus. Intra-abdominal temperatures were obtained by use of a modified Mallinckrodt critical care HiLo thermal sensor. This device was placed into the abdominal cavity via a 14 gauge Teflon catheter sheath placed in the right or left lower quadrant and positioned to avoid contact with any intra-abdominal structure or endoscopic instrument. Temperature assessment was by a Hewlett Packard EKG and temperature monitor (78353 B).

Carbon dioxide pneumoperitoneum was accomplished by use of a R. Wolf or Weiss insufflator. Core and intraabdominal temperatures was evaluated at incremental volumes of consumed carbon dioxide. A Marlow insufflator filter/tubing device (88-5050) was used to connect and deliver the carbon dioxide from the insufflator to the Veress needle.

Preinduction and operative anesthetic drugs included appropriate calculated doses of tubocurarine chloride, alfenta hydrochloride, droperidol, thiopental sodium, succinylcholine chloride, atracurium besylate, edrophonium chloride, atropine sulfate, glycopyrolate, neostigmine methylsulfate and inhalation oxygen, isoflurane, and nitrous oxide. All patients had endotracheal intubation with respiratory water vapor and thermal stabilization using a passive heat humidifier in the breathing circuit (Brethaid). An end-tidal carbon dioxide analyzer was used to assess alveolar carbon dioxide concentration throughout the procedures.

After induction of anesthesia, patients were exposed from just below the breasts to ankles. Prepping took 3–5 minutes using a warmed mixture of Hibiclens and sterile water. Draping was done with a Barrier Laparoscopy Pack II, covering both legs to the groin, abdomen, chest, and upper extremities, exposing the perineum and pubis to just above the umbilicus in a centimeter rectangle. Commercially available carbon dioxide was used to create the pneumoperitoneum. Intraperitoneal pressures were maintained below 20 mmHg.

A group of 40 females with breast or arthroscopic surgery served as the control group. In these patients, temperature assessment was performed pre- and postoperatively by tympanic evaluation, and intraoperatively by core esophageal temperature monitoring at the same timed intervals used in the study group.

RESULTS

Initial intra-abdominal findings were similar to initial core esophageal temperatures. Carbon dioxide temperature exiting the insufflator and Veress needle was recorded at 21.1–21.2°C. At a flow rate of 3 L/min a decrease of 2.8 ± 0.4°C intra-abdominal temperature was noted after insufflation of 5 L of carbon dioxide. The pneumoperitoneum created with 5 L of carbon dioxide when allowed to remain static, required 7.5 minutes to re-equilibrate to the initial intra-abdominal temperature. At a flow rate of 3 L/min, after consumption of 10 L carbon dioxide, it required 10 min $\pm$ 30 sec to return to the initial intra-abdominal temperature (Fig. 1)

Core temperatures decreased at a rate of 0.3°C for each 50 L carbon dioxide delivered for creation and maintenance of a pneumoperitoneum (Fig. 2). Greater thermal losses were observed with prolonged surgeries, a flow rate greater than 3 L/min, and with frequent gas extraction. The frequency of removal of carbon dioxide pneumoperitoneum correlated with larger total loss of temperature per unit of time.

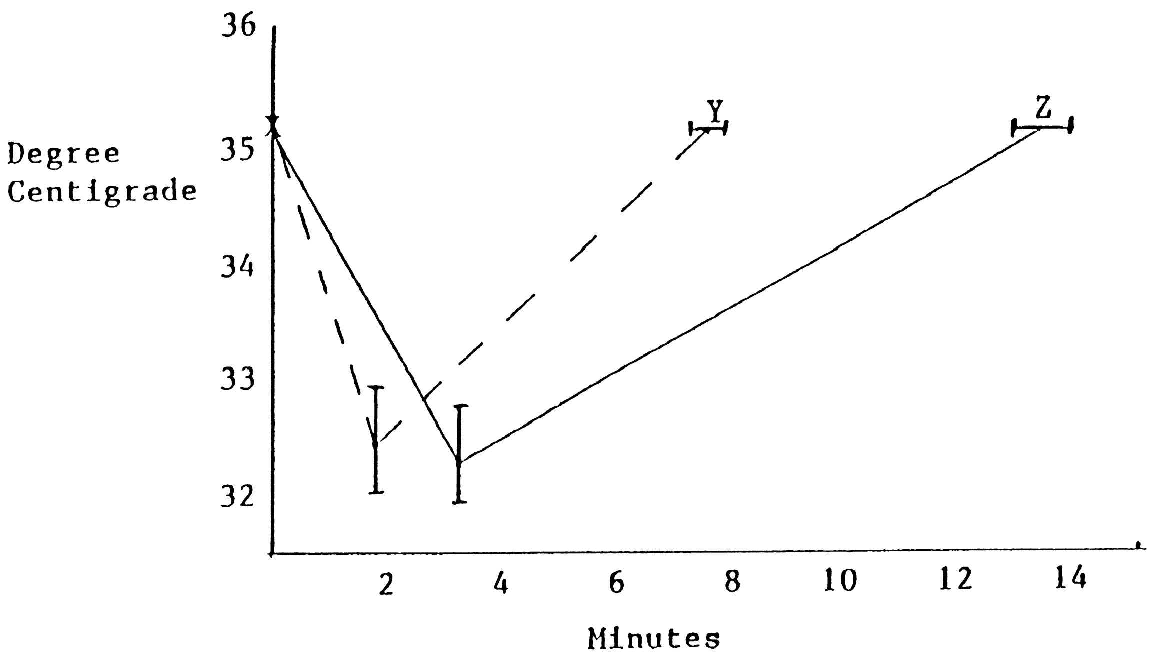

FIG. 1. Intra-abdominal temperature changes with a 3 liter per minute flow to 5 liters (---) and to 10 liters (——). X is the initial average intra-abdominal temperature. Y is the average length of time to regain the initial intra-abdominal temperature from a 5 liter static pneumoperitoneum. Z is the average length of time to regain the initial intra-abdominal temperature from a 10 liter static pneumoperitoneum.

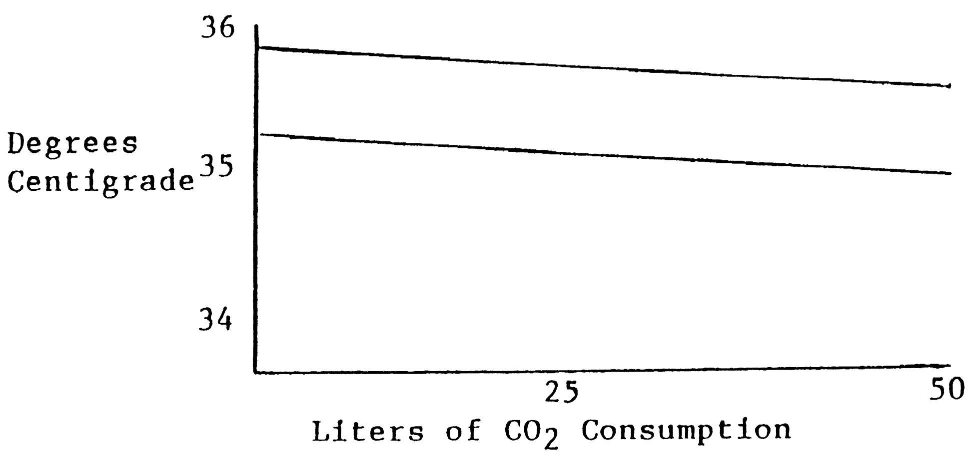

FIG. 2. Average core temperature decrease of 0.3° Centigrade per 50 liters of carbon dioxide consumed.

In the control group preoperative temperatures were statistically similar to the study group. The control group had stable intra- and postoperative temperature findings, which when compared with the study group varied significantly. Operating time and intravenous fluid consumption were not significantly different between the groups.

DISCUSSION

Carbon dioxide, a physiologic end product that is easily exhaled through the pulmonary alveoli, is the agent of choice for creation of a pneumoperitoneum.[7] Its tissue solubility exceeds that of oxygen by a factor of 10 and has a very high plasma solubility.[8] It does not support combustion. It is rapidly absorbed and excreted, and the risk of gas embolism using carbon dioxide is extremely low.[9] Commercially available carbon dioxide is contained in steel alloy cylinders as a liquid under its own vapor pressure of 5.727 Pa (830 psig) and changes to a gas at its boiling point of 21.1°C.

A survey of thermal gradients throughout the pelvis to define the range of temperatures likely to be met in tissues whose blood flow was being assessed has been described by Malkinson et al.[10] Findings included the observation that the vasodilatory effect of carbon dioxide was not important to thermal consequences. No mention was made regarding insufflated carbon dioxide volumes or rate of instillation, time elapsed during the observations, or temperature observations after the pneumoperitoneum was released. A general statement concerning geriatric surgery that "Hypothermia can be a major problem for the elderly" is noted but lacked quantitative data.[11] Martin also noted a reported complication of laparoscopy, transient hypothermia, but references were not cited.[7]

The mesenteric circulation receives 10% of the cardiac output.[12] The estimated surface area of the peritoneal cavity is equal to the external body surface area (1–2 m^2).[13] With this large area available as an interface for heat exchange a gradient is established which allows loss of core temperature to occur. A progressive heat loss of 0.3°C was found to occur per 50 L of carbon dioxide consumed. When added to other sources of operative and anesthetic circumstances, this thermal loss is cumulative and becomes an additional component of hypothermic risk.

With the insufflation of carbon dioxide at 21.1°C into an abdominal cavity at 35.5–36.2°C, a differential gradient occurs with a thermal decrease from the initial core temperature being realized. At a low flow insufflation rate (1 L/min) stabilization of intra-abdominal temperature occurs more rapidly than with higher flow rates. The greater temperature losses found at the higher flow rates is postulated to be a function of intra-abdominal evaporation and convection.

As a result of many factors, large volumes of carbon dioxide are required to maintain separation of the abdominal wall and intraperitoneal structures. Replacement of pneumoperitoneum losses, which occur mainly due to evacuation of the gas for maintenance of a clear visual field, but also at trocar incision locations, through instrument components (gaskets, seals, and valves) and with removal and placement of the laparoscope and operative instruments, is necessary. The use of carbon dioxide for creation and maintenance of pneumoperitoneum in relation to time, flow rate, and volume of gas used, resulted in an observed core temperature decrease of 0.3°C per 50 L consumed. This subtle but persistent temperature loss contributes to the total hypothermic risk patient's experience as a result of laparoscopy.

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