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EFFECT OF CARBON DIOXIDE FOR LAPAROSCOPIC CHOLECYSTECTOMY ON ARTERIAL PRESSURE IN OBESE AND NONOBESE PATIENTS

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SUMMARY – The effect of carbon dioxide induced pneumoperitoneum and anti-Trendelenburg's position on arterial pressure was retrospectively analyzed in 34 patients with cholelithiasis and overweight and 34 patients with cholelithiasis and normal body weight. According to general condition, all patients belonged to ASA II and ASA III groups. Upon induction in general endotracheal balanced anesthesia, patients received intermittent positive pressure ventilation. At the time of arterial pressure measurement, the following parameters were determined: respiratory volume 12 mL kg^{-1} body weight, respiration rate 12 breaths *per* minute, and inhalation to exhalation time ratio I:E=1:2. Arterial pressure was measured by automated noninvasive method in horizontal position before induction in general anesthesia (T1), upon induction in general anesthesia (T2), upon carbon dioxide inflation into abdominal cavity and anti-Trendelenburg's position at 25° (T3), upon carbon dioxide deflation from abdominal cavity (T4), and upon completion of the operation and patient extubation (T5). Arterial pressure showed a statistically significant increase after carbon dioxide inflation and a statistically significant decrease upon carbon dioxide deflation ($p<0.002$ both) in both study groups. In overweight patients, both systolic and diastolic pressure increased with carbon dioxide induced pneumoperitoneum to a mean value of 167±18 mm Hg and 102±10 mm Hg, respectively, as measured at T3. In the group of patients with normal body weight, the respective pressure values were 156±19 mm Hg and 98±9 mm Hg at the same time point.

Key words: *Laparoscopic cholecystectomy; Pneumoperitoneum; Carbon dioxide; Intra-abdominal pressure; Overweight; General endotracheal balance anesthesia*

Introduction

Laparoscopic cholecystectomy is a current method of surgical removal of the gallbladder. Since 1989, the method has found wide use all over Europe and America. Laparoscopic cholecystectomy has a number of advantages over classic cholecystectomy: lesser surgical incision of the abdominal wall, diminished metabolic response to stress owing to less operative tissue destruction, less postoperative ileus, lower need of postoperative analgesia, minimal postoperative immobilization, reduced time to recovery and length of stay at surgical department (2-3 days), 15 days to resuming full work ability, and cost-effectiveness[1]. However, the method may also be associated with some complications, especially in overweight patients[2], such as hemodynamic changes due to the effect of pneumoperitoneum, systemic CO_2 absorption, gas inflation and passage beyond the target area, air embolism, and lesions of visceral organs[1]. Therefore, the role of the anesthesiology team, appropriate anesthesiology instrumentation, and close patient monitoring during the operative procedure and anesthesia are of utmost importance. Intraoperative patient monitoring should include electrocardiography (ECG), noninvasive arterial blood pressure, carbon dioxide at the end of exhalation (ET CO_2), arterial blood oxygen saturation, airway pressure, muscle relaxation monitoring by neuromuscular stimulator, and body tem-

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perature. As this operative technique requires special patient treatment during anesthesia, general endotracheal anesthesia with a nasogastric tube, controlled ventilation and appropriate neuromuscular relaxation is preferred over other types of anesthesia and is recommended for laparoscopic procedures[3,4].

On preoperative preparation and during the procedure, care should be taken of various comorbidities that may entail considerable complications during laparoscopic operation. Overweight should be considered a comorbidity in patients with cholelithiasis because obese subjects frequently have impaired ventilation parameters and elevated blood pressure[5]. The aim of the study was to determine the possible occurrence of statistically significant and clinically relevant pressure changes due to pneumoperitoneum for laparoscopic cholecystectomy, and the possible difference in the arterial pressure variation between obese and nonobese patients.

Patients and Methods

Data were retrospectively collected from patient anesthesia charts. All 68 study patients belonged to ASA II and ASA III groups, divided into two groups of 34 patients: group A, patients with cholelithiasis and overweight, and group B with cholelithiasis and normal body weight. Upon intravenous premedication (midazolam 5 mg, fentanyl 0.05 mg, atropine 0.5 mg), general anesthesia was induced with thiopental (3-5 mg kg^{-1} body weight) and fentanyl (0.05 mg). Orotracheal intubation was performed with disposable plastic balloon tubes with succinyl at a dose of 1-1.5 mg kg^{-1} body weight. Intraoperatively, muscular relaxation was maintained by vecuronium at an initial dose of 0.08 mg kg^{-1} body weight. Anesthesia was maintained by fentanyl at a dose of 0.05-0.15 mg, depending on the length of operation, 60%-65% nitrous oxide in oxygen, and sevoflurane at a dose of 0.8-1.5 volume percent, depending on the arterial pressure elevation upon carbon dioxide inflation into the abdominal cavity. Efforts were made to maintain arterial pressure within ±20% of the initial value. Patients received artificial ventilation with intermittent positive pressure (IPPV) with inflation to exhalation time ratio I:E=1:2, respiration rate 12±2 breaths *per* minute (depending on $ETCO_2$), and respiratory volume (V_T) 10-12 mL kg^{-1} body weight. Patients were continuously monitored during the surgery and anesthesia. The monitoring included arterial pressure, pulse rate, carbon dioxide partial pressure at the end of exhalation ($ETCO_2$), and oxygen inspiration fraction (FiO_2). Pneumoperitoneum was maintained by carbon dioxide at a pressure of 12-14 mm Hg. Arterial pressure was measured at the following time points: 5 minutes before induction in general anesthesia in horizontal position as baseline value of arterial pressure (T1); 5 minutes of general anesthesia induction (T2); 5 minutes of carbon dioxide inflation in abdominal cavity and anti-Trendelenburg's position at 25° (T3); 5 minutes of carbon dioxide deflation from abdominal cavity (T4); and 5 minutes of the completion of the operation and patient extubation (T5).

Statistical analysis included mean and range, and t-test[6,7]. Statistical significance of systolic and diastolic pressure increases as independent variables was assessed by t-test for the following variables: 1) systolic and diastolic pressure before and after CO_2 inflation; and 2) systolic and diastolic pressure after CO_2 inflation and deflation in the group of overweight and normal weight patients in separate.

Results

Group A (Dg. *Cholecystitis calculosa, adipositas*) included 34 patients, 25 female and nine male, mean age 55±11 (range 29-78) years, mean body weight 99±12 (range 85-130) kg. Group B (Dg. *Cholecystitis calculosa*) included 34 patients, 29 female and five male, mean age 47±14 (range 26-74) years, mean body weight 69±8 (range 55-80) kg.

Systolic and diastolic arterial pressure values and changes before and during general anesthesia and laparoscopic cholecystectomy with carbon dioxide induced pneumoperitoneum in overeweight patients are present-

Table 1. Arterial pressure changes in overweight patients before induction in general anesthesia (baseline, T1), 5 min of induction in general anesthesia (T2), 5 min of carbon dioxide inflation into abdominal cavity and anti-Trendelenburg's position at 25° (T3), 5 min of carbon dioxide deflation from abdominal cavity (T4), 5 min of operation completion and patient extubation (T5)

Time point	Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)
T1	145±18	84±10
T2	138±13	85±10
T3	167±18	102±10
T4	150±18	92±11
T5	158±20	94±12

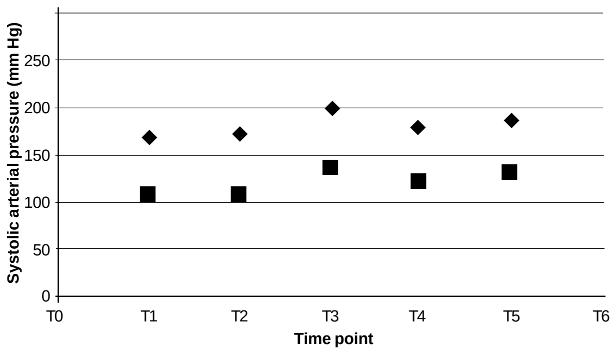

Fig. 1. Systolic pressure range in overweight patients.

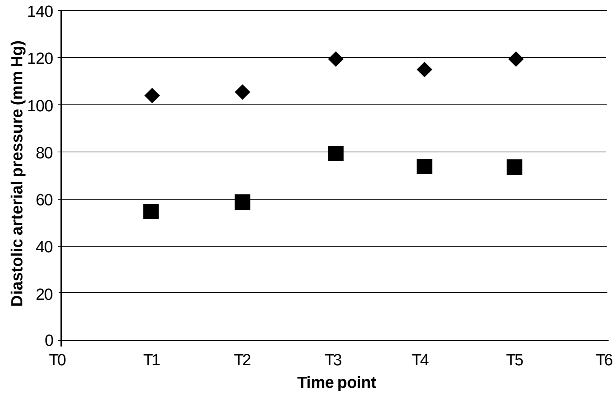

Fig. 2. Diastolic pressure range in overweight patients.

ed in Figures 1 and 2, and those in normal weight patients in Figures 3 and 4.

In overweight patients, systolic arterial pressure increased upon carbon dioxide induced pneumoperitoneum (T3) to 167±18 mm Hg. At the same time point (T3), diastolic pressure also showed an increase (102±10 mm Hg). Upon carbon dioxide deflation from abdominal cavity (T4), systolic pressure declined to 150±18 mm Hg and diastolic pressure to 92±11 mm Hg (Table 1).

In normal weight patients, systolic arterial pressure increased upon carbon dioxide inflation in abdominal cavity (T3) to 156±19 mm Hg. At the same time point (T3), diastolic pressure increased to 98±9 mm Hg. Upon carbon dioxide deflation from abdominal cavity (T4), systolic pressure declined to 142±17 mm Hg and diastolic pressure to 86±10 mm Hg (Table 2).

Carbon dioxide inflation led to a statistically significant increase in both systolic and diastolic pressure in both patient groups ($p<0.002$; d.f.=66). Carbon dioxide deflation resulted in a statistically significant decrease in both systolic and diastolic pressure in both patient groups ($p<0.002$; d.f.=66).

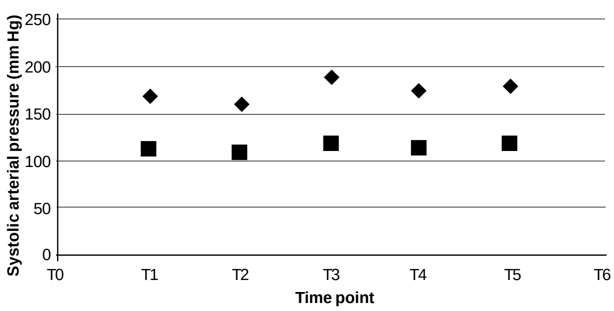

Fig. 3. Systolic pressure range in normal weight patients.

Discussion

This retrospective study demonstrated that carbon dioxide induced pneumoperitoneum during laparoscopic cholecystectomy caused arterial pressure changes in both study groups. A statistically significant increase of arterial pressure was recorded which, according to many authors, is consequential to direct mechanical effect of carbon dioxide on intra-abdominal pressure, its possible indirect cardiac effect, and direct effect on the vegetative sympathetic nervous system[1,8-10]. Besides the mechanical action upon the cardiovascular system, carbon dioxide pneumoperitoneum leads to considerable impairment of respiratory mechanics and gas exchange in terms of reduced lung and thoracic wall distensibility with retention of absorbed carbon dioxide and PaO_2 decline in obese patients[11].

Intra-abdominal pressure elevation influences systemic vascular resistance, venous blood flow and heart

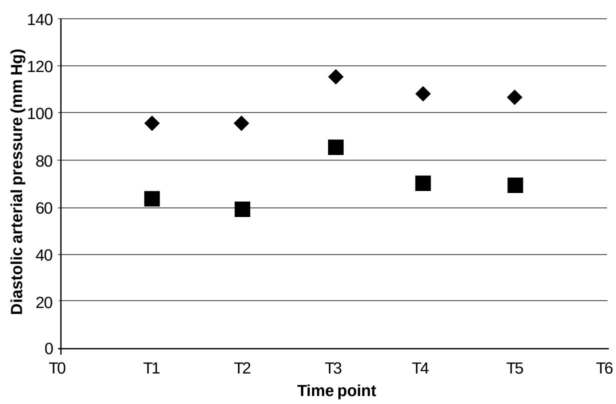

Fig. 4. Diastolic pressure range in normal weight patients.

Table 2. Arterial pressure changes in normal body weight patients before induction in general anesthesia (baseline, T1), 5 min of induction in general anesthesia (T2), 5 min of carbon dioxide inflation into abdominal cavity and anti-Trendelenburg's position at 25° (T3), 5 min of carbon dioxide deflation from abdominal cavity (T4), 5 min of operation completion and patient extubation (T5)

Time point	Systolic pressure (mm Hg)	Diastolic pressure (mm Hg)
T1	135±15	79±9
T2	129±13	80±11
T3	156±19	98±9
T4	142±17	86±10
T5	149±18	87±10

action. Systemic vascular resistance increases proportionally with the intra-abdominal pressure elevation. The effect on venous blood flow and heart action depends on the intra-abdominal pressure level[1,12]. A gradual increase in intra-abdominal pressure of 11-14.7 mm Hg is well tolerated by a healthy body, whereas stepwise increase to 18 mm Hg leads to cardiac output increase. An intra-abdominal pressure increase above 18 mm Hg results in intrathoracic pressure and airway pressure elevation due to craniad shift of the diaphragm. This results in central venous pressure elevation, hypertension and tachycardia. Upon intra-abdominal pressure increase above 20 mm Hg, vena cava is impressed and blood supply from lower parts of the body is precluded, leading to hypotension, tachycardia, drop in cardiac output and central venous pressure decline[1,12].

In the study patients, the intra-abdominal pressure thus produced rarely exceeded 12 mm Hg, which led to cardiovascular effects that were statistically significant, yet the pressure increase upon the establishment of pneumoperitoneum was clinically negligible. The fact that the pressure increase in obese patients did not differ significantly from that recorded in normal weight patients could be attributed to the moderate levels of intra-abdominal pressure, high operative team skillfulness, having completed the procedure within 20-40 minutes in the majority of cases, and use of balanced operative technique allowing for rapid and efficient prevention or correction of any untoward effects of carbon dioxide pneumoperitoneum.

Conclusion

This retrospective study showed the intra-abdominal pressure increase due to carbon dioxide pneumoperitoneum and carbon dioxide to lead to a statistically significant arterial pressure elevation ($p<0.002$) in both obese and nonobese patients. Thus, with the use of balanced anesthesia, both patient groups showed an identical pattern of arterial pressure changes that lasted for a short period of time, could be in part corrected by inhalation anesthesia and hyperventilation, and had no clinical relevance.

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Sažetak

DJELOVANJE UPUHIVANJA UGLJIČNOG DIOKSIDA U TRBUŠNU ŠUPLJINU KOD LAPAROSKOPSKIH KOLECISTEKTOMIJA NA ARTERIJSKI TLAK U PRETILIH I NEPRETILIH BOLESNIKA

N. Vranko i *I. Šklebar*

Retrospektivno je analizirano djelovanje pneumoperitoneuma izazvanog ugljičnim dioksidom i anti-Trendelenburgova položaja na arterijski tlak u 34 bolesnika s kolelitijazom i prekomjernom tjelesnom težinom i 34 bolesnika s kolelitijazom i normalnom tjelesnom težinom. Svi su bolesnici prema općem stanju pripadali skupinama ASA II. i ASA III. Nakon uvoda u opću endotrahealnu balansiranu anesteziju bolesnici su umjetno ventilirani intermitentnim pozitivnim tlakom (IPPV). U vrijeme mjerenja arterijskog tlaka zabilježeni su slijedeći parametri: respiracijski volumen 12 mL kg^{-1} tjelesne težine, frekvencija disanja 12 udisaja u minuti, odnos udisajnog i izdisajnog vremena I:E=1:2. Arterijski tlak mjeren je automatski neinvazivno u vodoravnom položaju prije indukcije u opću anesteziju (T1), nakon uvoda u opću anesteziju (T2), nakon upuhivanja ugljičnog dioksida u trbušnu šupljinu i anti-Trendelenburgova položaja od 25^o (T3), nakon ispuhivanja ugljičnog dioksida iz trbušne šupljine (T4) i nakon završetka operacije i ekstubacije bolesnika (T5). Arterijski tlak nakon upuhivanja ugljičnog dioksida u trbušnu šupljinu pokazao je statistički značajan porast ($p<0,002$) u obje analizirane skupine. Nakon ispuhivanja ugljičnog dioksida iz trbušne šupljine u obje analizirane skupine arterijski tlak je pokazao statistički značajan pad ($p<0,002$). Sistolični tlak u bolesnika s prekomjernom tjelesnom težinom je porastao nakon pneumoperitoneuma izazvanog ugljičnim dioksidom, srednja vrijednost 167±18 mm Hg (T3). Dijastolični tlak u istih bolesnika je također porastao, srednja vrijednost 102 ±10 mm Hg (T3). U skupini bolesnika normalne tjelesne težine sistolični je tlak dosegao srednju vrijednost od 156±19 mm Hg, a dijastolični 98±9 mm Hg u isto mjerno vrijeme.

Ključne riječi: *Laparoskopska kolecistektomija; Pneumoperitoneum; Ugljični dioksid; Intraabdominalni tlak; Prekomjerna tjelesna težina; Opća endotrahealna balansirana anestezija*