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The Effect of Different Levels of Elevated Artificial Pneumoperitoneum Pressure on the Cerebral Perfusion Pressure During Laparoscopic-Cholycystectomy

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Abstract

Background and Aims

With increasing laparoscopic surgeries there is a lot of argument about its techniques as regard method for peritoneal cavity approach by creating pneumo-peritoneum using Veress needle which may have many effects on cerebral perfusion state and oxygen consumption. This study tried to investigate the changes in cerebral perfusion pressure and cerebral oxygen extraction aiming to define the appropriate one maintaining the cerebral perfusion pressure.

Methods and Material

This prospective, randomized clinical trial was conducted on 40 patients scheduled for elective laparoscopic cholycystectomy surgery, 20-59 years old, of either sex ASA I – II. Patients were randomly assigned into two groups to receive either: intra-peritoneal pressure of 12 mmHg (PL) group and (PH) group: intra-peritoneal pressure of 20 mmHg.

Statistical Analysis

Data were analyzed using SPSS software version 21. Data were tested by Klomogorov-Smirnov test, student t-test, Mann-Whitey U test and Chi-square or Fisher's exact test as appropriate. P value < 0.05 was considered statistically significant.

Results

No significant differences in HR, SaO_2 and $Et.Co_2$ between both groups. MAP and CPP were lower in (PH) group versus (PL) group at 2nd intraoperative reading. CPP at 2nd intraoperative reading was lower in both group compared to basal value, MAP in (PH) group was lower and JBP was higher at 2nd intraoperative reading than basal value. PaO_2 and (COER %) were lower in (PH) in comparison to (PL) group at 2nd intraoperative reading, also PaO_2 was lower in (PH) compared to basal value at 2nd intraoperative reading.

Conclusions

During laparoscopic cholycystectomy, temporary high pressure needed during insertion of Verss needle is associated with decrease in cerebral blood flow and intracranial pressure. Although these changes decrease cerebral perfusion pressure and oxygenation, they are transient and of no significant clinical effects.

Keywords: Different levels artificial pneumo-peritoneum pressure; Cerebral perfusion pressure; Laparoscopic cholycystectomy

Introduction

In spite of increasing the usage of laparoscopic surgical techniques in different surgical fields as it provides less traumatic and more cosmetic ways for surgical intervention, there is still a lot of argument about multiple aspects of its techniques. One of the main argues issue is the optimal method of creating the pneumo-peritoneum. There are no consensus exists as regard the best method for accessing the peritoneal cavity with regard to the establishment of pneumo-peritoneum, the puncture with Veress needle represents the most popular technique [1]. Many complications in laparoscopy procedures occur at the start of the procedure, either during the introduction of the Veress needle or the first trocar [2]. In previous study it is proved that Veress needle and the first trocar cause injuries up to 0.04% of gastrointestinal lesions and 0.02% of vascular lesions. The incidence of these complications are rare however their consequences are deadly. It is well known that blind insertion of Veress needle into the midline of the abdomen at the level of the umbilicus at intra-peritoneal pressure of 10 and 12 mmHg; may cause many serious injuries [3]. Very high pressure caused by an artificial pneumo-peritoneum, for a period just sufficient for the blind introduction of the first trocar, in the closed method, can effectively protect the intra-abdominal structures against injury [4]. Also, low vascular injury incidence was reported in a study when using blind insertion of the first trocar in the midline with an intra-abdominal pressure below 25-30 mmHg [5]. Another studies confirmed that high intra-peritoneal pressures provide a better trocar slippage into the cavity and make the abdominal wall tenser and reduces its elastic deformation caused by a force applied to the trocar [6]. Meanwhile, the high pneumo-peritoneum pressures over a prolonged period of time can cause hemodynamic changes in the body. Thus, under high intra-peritoneal pressures, decreases in cardiac output and venous return, raising of mean arterial pressure and systemic vascular resistance and diversity in renal perfusion and glomerular filtration were demonstrated, in addition, ischemic lesion and reperfusion injury of intra-abdominal organs [7]. Despite the above considerations, no researches investigate cerebral perfusion state and oxygen consumption in patients undergoing high transient intra-peritoneal pressure. This means that laparoscopic surgeons may down size the considerations about safe strategy for first trocar entry together with brain perfusion.

Aim of the Study

This study tried to improve the safety of the introduction of the first trocar and investigate the changes in cerebral perfusion pressure and cerebral oxygen extraction caused by high transient pneumo-peritoneum pressures for short periods of time aiming to define the most appropriate one maintaining the cerebral perfusion pressure within accepted range.

Materials and Methods

For this prospective, randomized clinical trial, authorization was obtained from the Research Ethics Committee of Mansoura University. The study was conducted at Mansoura University Hospital in Mansoura city, starting from December 2014 until January 2015 All patients who were scheduled for elective laparoscopic surgery, between 20 and 59 years old, of either sex classified into ASA I-II according to their physical condition, with no history of abdominal surgery on organs located at the abdominal supra-mesocolic level, without previously diagnosed peritonitis and with body mass index (BMI) less than 35, and gave written consent were included in the studied. Upon obtaining odd and even numbers on the upper face of a dice rolling, patients were randomly assigned to group L: (intra-peritoneal pressure of 12 mmHg) and group H (intra-peritoneal p: pressure of 20 mmHg). All patients were evaluated in anesthetic clinic prior to the date of surgery. Before starting anesthesia, modified Allen test was performed. All patients were hydrated with Ringer acetate after insertion of 18G cannula. The patients were monitored by standard monitoring: ECG, pulse oximetry, non-invasive blood pressure and capnometry. All patients received general anesthesia, induced by fentanyl 1 mcg/kg, rocuronium 1 mg/kg and propofol 2 mg/kg. Anesthesia was maintained with sevoflurane in a mixture of oxygen and compressed air. All patients were mechanically ventilated with volume controlled ventilation using Fabius GS Drager anesthesia machine with Dixtal model DX 2010 monitors. Initial ventilation was achieved with a fraction of inspired oxygen of 60%, positive end expiratory pressure (PEEP) = 6 cm H_2O, tidal volume = 7 mL/kg, respiratory rate = 15 breaths per minute and inspiration/expiration ratio = 1:2. With the establishment of an appropriate anesthetic plan and a negative Allen test, the radial artery was catheterized in the non-dominant hand for arterial pressure monitoring and blood gas analysis. A jugular bulb cannula was inserted for cerebral venous pressure monitoring and blood gas analysis, by retrograde cannulation of the internal jugular vein distally where it courses close to the skin between the two heads of the sternocleidomastoid muscle, by using a Seldinger technique and the catheter was advanced into the bulb at about 12±1.5cm thus position of the catheter tip must be ascertained by X-ray to ensure accurate measurement and reduce complications. All operations were performed by the same surgeon and the anesthesiologists who administer the anesthetics was not involved in the patients' assessment. All the other staff in the operating room were unaware of the randomization code. Pneumo-peritoneum was created by closed technique with abdominal puncture through the Veress needle and CO2 flow of 1 L/min and the intra-abdominal insufflation pressure was limited to 12 mmHg (P12 group) or 15 mmHg (P15 group). During the procedure, blood gas analysis pH, PaO_2 (mmHg), $PaCO_2$(mmHg), HCO_3(mmol/L), BE (mmol/L) were done with a blood gas analyzer Rapidlab 348 BayerHealth Care, Model 348 pH/Analyzer SN 6678. Also MAP, jugular bulb pressure, cerebral perfusion pressure, arterial O_2 content, jugular bulb O_2 content and cerebral O_2 extraction ratio were monitored and calculated. For estimation, cerebral oxygenation state and cerebral oxygen extraction ratio (COER) were calculated using the following equations:

$Cao_2 = (Sao_2 \times Hb \times 1{:}39) + (0{:}031 \times Pao_2)$

$Cjvo_2 = (Sjvo_2 \times Hb \times 1{:}39) + (0{:}031 \times Pjvo_2)$

$Cajo_2 = (Cao_2 - Cjvo_2)$

$COER = 100 \times Cajo_2 / Cao_2$ where CaO_2 and $CjVO_2$ are the arterial and jugular venous bulb oxygen contents.

These parameters were evaluated in both groups at time zero, before pneumo-peritoneum at:

1- Basal reading.

2- 1st intraoperative reading, when IPP reaches12 mmHg in both groups.

3- 2nd intraoperative reading, after 5 min with IPP = 12 mmHg in group L and after 5 min with IPP = 20 mmHg in group H.

4- 3rd intraoperative reading, after 10 min with IPP = 12 mmHg in group L and with return of IPP from 20 to 12 mmHg in group H.

5- 4th intraoperative reading, counted 10 min after return of IPP to 12 mmHg in both groups.

All patients were monitored during the anesthetic-surgical procedure through the following parameters: heart rate and rhythm, pulse oximetry, capnometry ($EtCO_2$) and mean arterial pressure. In post-anesthesia recovery room, heart rate and rhythm, mean arterial pressure, pulse oximetry, were observed, until patients' discharge to the ward. HR less than 75 b/min.; MAP between 70 -120 mmHg; SaO_2 greater than 93%; EtCO2 between 30 and 45 mmHg; pH between 7.35 and 7.45, $PaCO_2$ between 30 and 45 mmHg; PaO_2 above 80 mmHg; BE between −2 and +2; and HCO_3 between 22 and 26 mEq/ L were considered normal values.

Power of Study

Based upon the data from our pilot study, CPP in group L, at 2nd intraoperative reading was 60 with a standard deviation of 9. An a priori power analysis showed that we needed to include 17 cases in each group to detect 20% reduction in CPP at 2nd intraoperative reading with an alpha error of 0.05 and a power of 85%. We increased the number of cases by 15% in order to compensate for dropping out during recruitment.

Statistical Analysis

Data obtained were statistically analyzed using SPSS software version 21. Data were first tested for normality by Klomogorov-Smirnov test. Normally distributed continuous data were analyzed by using student t-test. Non-normally distributed continuous and ordinal data were analyzed using Mann-Whitey U test. Categorical data were analyzed by Chi-square or Fisher's exact test as appropriate. The results were presented as mean (SD), or number and % of patients as appropriate. A P value < 0.05 was considered statistically significant.

Results

Forty patients in two groups completed the study. No statistically significant differences were found between two groups as regard age, sex, weight, height, anesthesia and operation time (Table 1).

Table 1: Demographic data of the studied groups, data are expressed as number, mean ± SD.

	Group L (n=20)	Group H (n=20)	P value
Age (years)	37 ± 6	38 ± 5	0.774
Weight (Kg)	56 ± 12	57 ± 11	0.642
Height (cm)	153 ± 9	152 ± 7	0.981
Sex (M:F) *no*	4 / 16	3 / 17	0.793
Anesthesia time (minutes)	66 ± 12	68 ± 11	0.607
Operation time (minutes)	53 ± 13	51 ± 12	0.365

No statistically significant differences in heart rate, peripheral oxygen saturation and end tidal Co_2 when both groups were compared together (Table 2).

Table 2: Heart rate (b/min.), SpO_2 (%) and end tidal CO_2 (mmHg) of the studied groups, data are expressed as mean ± SD.

	Heart rate			End tidal CO_2			SpO_2		
	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value
Basal	84±12	86±14	0.872	34±3	35±1	0.941	99±2	99±1	0.811
1st IO	75±13	79±11	0.971	35±2	36±2	0.455	99±1	99±2	0.547
2nd IO	76±12	71±15	0.932	31±3	31±1	0.876	99±1	99±1	0.623
3rd IO	74±10	72±13	0.824	34±2	29±3	0.821	99±2	100±1	0.471
4th IO	75±11	79±16	0.818	35±4	35±2	0.734	100±1	99±2	0.514
Basal ICU	86±15	88±13	0.792				97±2	98±1	0.371
1st ICU	82±13	84±12	0.621				98±1	98±2	0.486
2nd ICU	83±14	80±13	0.734				96±2	97±1	0.589

Mean arterial pressure and cerebral perfusion pressure were lower in group H in comparison to group L at the second intraoperative reading. Cerebral perfusion pressure at the second intraoperative reading was lower in both group when compared to basal value similarly, mean arterial pressure in group H was lower than basal value and jugular pressure was higher at the second intraoperative reading (Table 3).

Table 3: Mean invasive arterial pressure (mmHg), jugular bulb pressure (mmHg) and cerebral perfusion pressure (mmHg) of the studied groups, data are expressed as mean ± SD.

	MAP			CPP			JBP		
	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value
Basal	82±9	81±10	0.803	70±11	71±13	0.43	12±3	10±3	0.209
1st IO	76±9	77±8	0.063	62±10	62±10	0.46	14±2	15±1	0.211
2nd IO	75±11	65±9*	0.011	60±9†	47±9*†	0.79	15±1	18±2†	0.438
3rd IO	76±13	75±7	0.829	62±9	62±10	0.48	14±2	13±4	0.590
4th IO	79±7	78±9	0.570	69±12	67±11	0.22	10±2	11±4	0.510

* p< 0.05 is considered significant when compared to P12 group.

† p< 0.05 is considered significant when compared to the basal value.

Arterial oxygen tension and cerebral oxygen extraction ratio were lower in group H when compared to group L at the second intraoperative reading, also Arterial oxygen tension was lower in group H when compared to the basal value at the second intraoperative reading (Table 4).

Table 4: Arterial O2 content or tension (PaO2), jugular bulb O_2 content or tension ($PJBO_2$), jugular venous oxygen saturation ($SJVO_2$)and cerebral oxygen extraction ratio (COER) (%) of the studied groups, data are expressed as mean ± SD.

	PaO_2			$PJBO_2$			$SJVO_2$			COER		
	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value	Group L(n=20)	Group H(n=20)	P value
Basal	224±16	216±17	0.49	60±8	61±10	0.87	71±7.2	70.6±9	0.93	30.89	30.40	0.821
1st IO	221±16	219±14	0.37	58±9	59±9	0.92	74.5±8	73.4±9	0.12	26.87	28.2	0.072
2nd IO	206±11	193±14*†	0.045	53±10	52±10	0.83	71.3±9.3	69.1±8	0.54	34.19	27.04*	0.143
3rd IO	203±12	205±13	0.33	53±8	51±9	0.68	70.4±8	69.1±7	0.92	35.86	32.65	0.481
4th IO	211±14	213±15	0.52	61±9	57±8	0.69	71.2±13	72.8±10	0.13	31.68	30.20	0.365

* $p < 0.05$ is considered significant when compared to P12 group.
† $p < 0.05$ is considered significant when compared to the basal value.

Discussion

No complications were recorded after surgery in form of delayed recovery, altered conscious level, babilloedema, focal or general neurological deficit. It is well known that, almost all complications which take place during laparoscopic procedures often occur at the beginning of the procedure either by gas insufflation or by raising the intra- abdominal pressure. Consequently, this study was design to compare two different levels of artificial pneumo-peritoneum during laparoscopic-cholycystectomy in order to achieve better hemodynamic stability, adequate cerebral perfusion together with reduction in perioperative untoward events. In this study, mean arterial pressure (MAP) and cerebral perfusion pressure (CPP) were found to be lower in P20 group in comparison to P12 group at the second intraoperative reading. In addition, (CPP) and (MAP) were lower in both groups when compared to the basal value. In order to perform any laparoscopic procedures, CO_2 is insufflated into the peritoneal cavity. This artificial Pneumo-peritoneum increases the intra-abdominal pressure, elevates the diaphragm and compresses both small and large blood vessels. The raised intra-abdominal pressure obtained during these procedures, which is usually around 12 mmHg increases central venous pressure (CVP), heart rate (HR), systemic vascular resistances (SVR) up to a 65%, and the pulmonary vascular resistances (PVS) can rise up to a 90%. In healthy patient, Cardiac output (CO) can increase in Trendelenburg position, but can also decrease up to a 50% on patients in anti-Trendelemburg position or with a low cardiovascular reserve. All these changes are usually well tolerated in healthy patients but it can be different in patients with systemic diseases. Llagostera-Pujol et al, in 2002 explain this by the intra-abdominal pressure reaches more than 15mmHg, can compress the cava vein, reducing the blood return which results in reduction of the cardiac output. Similarly, the diaphragm elevation will raise the intra thoracic pressure which will reduce the cardiac output. The lower CO can be compensated in a healthy patient by increasing the heart rate and arterial vasoconstriction, obtaining a stable hemodynamic status. Arrhythmia and bradycardia often appear in non atropinized patients during insufflatio [14].

However, it is not widely accepted to compromise hemodynamic and pulmonary functions by laparoscopy. In one study by Basim et al, 2005, they monitored non-invasively all cardiovascular parameters and pulmonary compliance during the initial entry using insufflation pressures up to 30 mm Hg. Although they found minor changes in cardiovascular parameters, and all of them reverted to normal values once the pressure was decreased to 15 mm Hg for the duration of the surgery. They found a gradual decrease in pulmonary compliance from the initial insertion of the Veres needle to a pressure of 15 mm Hg and an additional 21% decrease from 15- to 30 mm Hg. they concluded that although alterations in pulmonary compliance are statistically significant, they have no clinical significance and are tolerated well by healthy women. However, they recommended that all patients with compromised cardiopulmonary functions should not be exposed to such high pressures either during the initial entry to the abdomen or during the laparoscopic procedure itself. Such patients may be better served using alternative entry techniques or using lower intra-peritoneal pressures [14].

Furthermore, another study conducted by Abu-Rafea et al. 2005 showed no cardiopulmonary complications in 100 healthy women undergoing high intra-abdominal pressure (between 10 and 30 mmHg) during the introduction of the first trocar. The authors analyzed the volume of CO2 effectively inflated into the peritoneal cavity, heart rate, blood oxygen saturation, mean arterial pressure and pulmonary compliance. Although, the changes in MAP and pulmonary compliance were statistically significant, they were not clinically significant.

However, Abu-Rafea et al. did not set parameters to assess changes in respiratory function and gas exchange. Moreover, the effect of each pressure level (10, 15, 20, 25 and 30 mmHg) was evaluated at the exact moment it was achieved, without taking into account the cumulative effect of the duration of pneumo-peritoneum for insertion of the first trocar, and this makes difficult to assess the clinical effects resulting from the duration of pneumo-peritoneum, rather than from the level of intra-abdominal pressure reached [14].

The study by Fernando et al, 2011 aimed at evaluating whether intra-thoracic and abdominal pressure changes, in addition to oxygenation parameters, could cause an increase in intracranial pressure values. The study showed that the correlation between CVP and ICP may suggest an increase in venous pressures caused by increased thoracic and abdominal pressures which have limited the cerebral venous drainage, subsequently increasing ICP [15].

A study by Lee et al. 2006 observed the effect of gynecological laparoscopic surgery on cerebral oxygenation by changes in regional cerebral oxygen saturation (rSo_2). During the period of pneumo-peritoneum, rSo2 fell below 50% in two hypercapnic patients. In comparison with baseline, rSo2 declined significantly in the Trendelenburg position. The creation of pneumo-peritoneum itself did not decrease the average rSo_2 value further unless the patients were hypercapnic [16].

Another study by Hypólito et al. in 2010, showed that the high intra-abdominal pressure is a safe practice, and no adverse clinical effects were observed by non-invasive monitoring analysis [17].

The results detected by Hypolitoa et al., showed a statistically significant change was observed in MAP in both groups and throughout artificial pneumo-peritoneum. The fact that this change was also observed in P12 group would suggest that its cause was due to the effect of pneumo-peritoneum, even with a standard IPP. Even at low pressures (considered) (12 mmHg), a vasoconstriction reflex is triggered, with consequent increase in blood pressure. However, it is noteworthy that there was no case of hypertension in any of the groups. They reported that, the high (20 mmHg) and transient (5 min) intra-abdominal pressure for insertion of the first trocar causes changes in MAP, pH, HCO_3 and BE without clinical consequences for the patient and should be used to prevent the occurrence of iatrogenic injuries in the introduction of the first trocar [18].

Also, jugular arterial pressure (JBP) was higher at the second intraoperative reading in our study which is a result of increased Intra-thoracic (ITP) and intra-abdominal pressures (IAP) that are known to influence ICP. However, the magnitude of this effect and its clinical relevance, are unknown. Several researches have highlighted the impact of intra-abdominal pressure on critical disease pathophysiology. The magnitude of pressure's influence of thoracic and abdominal compartments with intracranial pressure in critical disease has been poorly studied. Intra-abdominal pressure can apparently affect intracranial pressure, likely because of increased venous and intra-thoracic pressures. Peritoneostomy has been described as a rescue therapy for refractory intracranial hypertension patients. this study, arterial oxygen tension and cerebral oxygen extraction ratio were lower in P20 when compared to P12 group at the second intraoperative reading, also Arterial oxygen tension was lower in P20 when compared to the basal value at the second intraoperative reading. This may attributed to the fact that, during laparoscopic surgery, there is frequently reported alterations in cerebral blood flow and intracranial pressure. These changes affect cerebral perfusion pressure and thus may affect cerebral oxygenation. Measurement of the saturation of brain effluent blood gives a global estimate of cerebral oxygenation. It may provide clinicians with information to assist in reducing secondary insults to the brain with potential benefit studied by (Macmillan and Andrews [19]).

Limitation of Study

The incidence of endobronchial intubation were lower than expected, hence we couldn't perform a regression co-relation analysis to find a solid predictive indicator for endobronchial intubation.

Conclusion

During laparoscopic cholycystectomy, temporary high pressure needed during insertion of Verss needle is associated with decrease of cerebral blood flow and intracranial pressure. Although these changes decreases cerebral perfusion pressure and cerebral oxygenation, they are transient and of no significant clinical effects.

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