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Original Article

Impact of gasless laparoscopy on circulation, respiration, stress response, and other complications in gynecological geriatrics

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Abstract: This study aimed to explore the impact of gasless laparoscopy on circulation, respiration, stress response and other complications in gynecological surgery for old female patients. 40 patients (American Society of Anesthesiologists II-III, 60-70y) scheduled for elective gynecological laparoscopy were divided into non-pneumoperitoneum group (NP) and pneumoperitoneum group (P). All patients included were monitored for Compliance, Ppeak, Ppalt, MAP, CVP, HR, S_pO_2, blood gas analysis (pH, P_aCO_2, and P_aO_2), serum cortisol, TNF-α, and IL-6. There were significant differences in bowel tones recovery, postoperative shoulder pain, nausea, and vomiting between two groups ($P < 0.05$). In the P group, the levels of CVP, and Ppeak and Ppalt at both 10 minutes and 30 minutes after suspension/pneumoperitoneum were significantly higher than those in NP group ($P < 0.05$). When it came to Compliance, this trend was reversed ($P < 0.05$). As surgery was conducted, the plasma concentrations of cortisol, IL-6 and TNF-α in the P group were higher than those in the NP group ($P < 0.05$). Thus, for gynecological diseases of geriatrics, the effect on respiratory and circulatory function is less significant of gasless laparoscopy than in pneumoperitoneum. The stress response, recovery of bowl tone, should pain, nausea, and vomiting after surgery in gasless laparoscopy is improved than in pneumoperitoneum.

Keywords: Non-pneumoperitoneum, gynecologic surgical procedures, laparoscopy, geriatrics, respiratory function, circulatory function, stress

Introduction

With the accelerated process of population aging in China, the number of elderly patients needing to receive surgical treatment is increasing. However, such patients often have chronic medical diseases of circulation, respiration and other systems which cause an increased difficulty of perioperative management and complications, and even some patients would give up due to fear of surgical risk. Laparoscopic surgery, with the advantages of less trauma and rapid recovery, is a better method for elderly patients [1]. However, CO_2 absorption and elevation of intra-abdominal pressure (IAP) from artificial pneumoperitoneum may further aggravate the condition of the existing circulation and respiration system disease to impact the postoperative recovery of the patients [2, 3]. The use of abdominal wall lifting technique in laparoscopy surgery avoids a series of complications caused by pneumoperitoneum and improves the surgical safety of the elderly patients with circulation and respiration system diseases [4-6]. In Maternal and Child Care Service Centre of Shanghai Jiading District, gasless laparoscopy was adopted for treatment of benign gynecologic tumors in elderly patients from January to December 2011, and the outcomes were compared to those of laparoscopy with pneumoperitoneum conducted during the same period and were analyzed. The results showed that a satisfactory outcome had been achieved. Now the details are reported below.

Subjects and methods

Subjects

This study was approved by The Ethics Committee of Shanghai Jiading District Ma-

Table 1. Comparison of general data, surgical situation and postoperative complications between the two groups (N = 20)

Groups	Age (y)	Body weight (kg)	Amount of bleeding (ml)	Duration of operation (min)	Recovery time of borborygmus (h)	Postoperative nausea and vomiting n (%)	Shoulder pain n (%)
Nonpneumoperitoneum group	65.3 ± 4.8	64.7 ± 3.8	143.2 ± 56.7	54.3 ± 18.9	15.3 ± 2.6	3 (15)	5 (25)
Pneumoperitoneum group	66.2 ± 5.7	66.4 ± 4.5	151.8 ± 50.9	61.2 ± 23.4	23.4 ± 4.7*	6 (30)*	12 (60)*

Footnote: *Compared to NP group, P < 0.05.

ternal and Child Care Service Centre, and the informed consent form had been signed. Forty elderly patients with benign gynecologic tumors (American Society of Anesthesiologists (ASA) II-III, 60-70y) who were admitted to the hospital for treatment from January to December 2011 were selected and were randomly divided into non-pneumoperitoneum group (NP, n = 20) and pneumoperitoneum group (P, n = 20) with digital table. Exclusion criteria: the patients in whom the duration of operation > 2 h, those with severe respiratory and circulatory system diseases and those at ASA IV.

Anesthesia and surgical procedures

The patients were not allowed to drink within 2 h, ingest dairy foods within 4 h and eat the solid food within 6 h before surgery. After entering the operating room, the patients were given monitoring of ECG, saturation of pulse oximetry (S_pO_2), non-invasive blood pressure and end-tidal carbon dioxide partial pressure ($p_{et}CO_2$), and the veins of upper limb were exposed. After rapid intravenous induction with midazolam (0.04 mg/kg), 40 mg lidocaine, propofol target-controlled infusion (TCI) (3 μg/mL), sufentanil (0.3 μg/kg) and rocuronium bromide (0.8 mg/kg), endotracheal intubation was performed and then mechanical ventilation was given (tidal volume (VT) = 8 ml/kg, respiratory rate (RR) = 12 bpm, inspiratory/expiratory (I:E) = 1:2, fraction of inspired oxygen (FiO2) = 100%). After anesthesia, the venipuncture was performed in the right neck to establish monitoring of central venous pressure (CVP). During the operation, the inhalation of sevoflurane and the intermittent intravenous addition of sufentanil and rocuronium bromide were performed to maintain the depth of anesthesia. The lithotomy position was taken in patients. After routine disinfection and draping, the ureter and uterine manipulator were placed. In the P group, Trendelenburg's position was taken, and umbilical opening was used as the puncture point; CO_2 was filled in the speed of 1~2 L/min with the automatic pneumoperitoneum machine to establish pneumoperitoneum, and IAP was maintained at 12 mmHg (1 mmHg = 0.133 kPa). In NP group, a 10 mm Trocar was punctured in the right superior border of navel, and laparoscope was placed; then Trendelenburg's position was taken, and kirschner wire (1.2-1.5 in diameter) was adopted to cross subcutaneously about 4 cm from the upper middle 1/3 part of medioventral line of the lower abdomen in a horizontal direction, which then was pierced out from the skin. Then the lifting devices were used to lift abdominal wall, and the lifting height was adjusted by lifting chain.

Observations

The mean arterial pressure (MAP), CVP, heart rate (HR), S_pO_2, chest and lung compliance, Ppeak and Pplat were recorded at four points: after anesthesia (T_1), 10 minutes after suspension/pneumoperitoneum (T_2), 30 minutes after suspension/pneumoperitoneum (T_3) and 10 minutes after removal of suspension/pneumoperitoneum (T_4), respectively; and the blood sample were collected from radial artery and upper limb vein at the corresponding time points to perform the blood gas analysis and monitor the levels of serum cortisol, IL-6 and TNF-α. The conditions of amount of bleeding, operation duration, postoperative nausea and vomiting, shoulder pain and recovery time of borborygmus in both groups were observed.

Statistical analysis

SPSS 11.0 was adopted. Measurement data was expressed as $\bar{x} \pm s$, and one-way analysis of variance was used for intra-group comparison; two-way analysis of variance was employed for inter-group comparison; enumeration data was expressed as a percentage; χ^2 test was adopted. $P < 0.05$ was considered statistically significant.

Table 2. Comparison of perioperative hemodynamic data in the patients between the two groups (n = 20)

Groups	Time points	MAP (mmHg)	CVP (cmH_2O)	HR (bpm)	S_pO_2 (%)
Nonpneumoperitoneum group	T_1	92.7 ± 8.4	11.2 ± 2.3	76.5 ± 3.4	99.8 ± 0.4
	T_2	96.4 ± 12.6	15.7 ± 3.5	82.4 ± 2.6	99.5 ± 0.3
	T_3	94.8 ± 9.3	16.2 ± 2.8	83.6 ± 3.5	99.4 ± 0.6
	T_4	89.3 ± 9.8	11.1 ± 2.8	78.5 ± 3.8	99.8 ± 0.5
Pneumoperitoneum group	T_1	95.5 ± 7.9	10.7 ± 2.5	78.1 ± 3.8	99.9 ± 0.3
	T_2	102.7 ± 10.2	23.1 ± 4.2*,#	84.5 ± 3.6	99.7 ± 0.6
	T_3	97.1 ± 7.9	23.4 ± 3.5*,#	84.2 ± 4.4	99.3 ± 0.7
	T_4	90.0 ± 8.2	12.1 ± 2.8	76.8 ± 2.6	99.7 ± 0.4

Footnote: 1 cmH_2O = 0.098 kPa; *compared with the data at T_1 in the same group, P < 0.01; #compared with the data at the same time point in NP group, P < 0.05.

Table 3. Comparison of perioperative pneumodynamics data in the two groups (n = 20)

Groups	Time points	Chest and lung compliances (mL/100Pa)	Ppeak (cmH_2O)	Pplat (cmH_2O)
Nonpneumoperitoneum group	T_1	52.3 ± 12.4	16.5 ± 3.4	14.8 ± 2.1
	T_2	43.9 ± 10.2	17.4 ± 2.3	15.4 ± 3.3
	T_3	45.1 ± 7.9	18.6 ± 2.6	15.8 ± 2.9
	T_4	48.3 ± 9.5	17.1 ± 1.8	16.8 ± 2.7
Pneumoperitoneum group	T_1	51.4 ± 8.9	18.1 ± 3.8	15.0 ± 2.3
	T_2	28.3 ± 7.6*,#	25.5 ± 4.6*,#	23.2 ± 3.9*,#
	T_3	27.5 ± 9.3*,#	25.8 ± 5.4*,#	23.7 ± 3.7*,#
	T_4	47.9 ± 9.2	18.4 ± 3.6	16.3 ± 3.5

Footnote: 1 cmH_2O = 0.098 kPa; *compared with the data at T_1 in the same group, P < 0.05; #compared with the data at the same time point in NP group, P < 0.05.

Results

General data, surgical situation and postoperative complications

No statistical difference was observed in the age, body weight, amount of bleeding during operation and duration of operation in the patients between the two groups ($P > 0.05$ for all above). In NP group, the postoperative recovery time of borborygmus and the incidence of postoperative nausea, vomiting and shoulder pain were all significantly lower than those in P group (both $P < 0.05$). See **Table 1**.

Hemodynamics

No statistical differences were observed in MAP, HR and S_pO_2 of the patients in the two groups at each time point ($P > 0.05$ for all above). The differences of CVP at different time points were all not statistically significant in NP group ($P > 0.05$); in P group, CVP at T_2 and T_3 were significantly higher than that at T_1 ($P < 0.01$) and then those at the same time point in NP group ($P < 0.05$). See **Table 2**.

Pneumodynamics

No statistical difference was observed in pneumodynamics parameters of the patients of NP group at the different time points ($P > 0.05$). As for the patients of P group, their chest and lung compliances at T_2 and T_3 were significantly lower than that at T_1 and obviously lower than those at the corresponding time point in NP group ($P < 0.05$), and Ppeak and Pplat at T_2 and T_3 were significantly higher than those at T_1 and obviously higher than those at the corresponding time point in NP group ($P < 0.05$). See **Table 3**.

Blood gas analysis during the surgery

The pH values of the patients of both groups showed a decrease trend after the start of anesthesia, but the difference relative to the baseline values at T_1 was not statistically sig-

Table 4. Comparison of intraoperative blood gas analysis data in the two groups (n = 20)

Groups	Time points	pH	P_aO_2 (mmHg)	P_aCO_2 (mmHg)
Nonpneumoperitoneum group	T_1	7.38 ± 0.13	458 ± 127	37.2 ± 3.8
	T_2	7.37 ± 0.17	435 ± 123	38.1 ± 3.3
	T_3	7.36 ± 0.19	449 ± 116	39.3 ± 3.5
	T_4	7.35 ± 0.16	461 ± 108	38.7 ± 2.6
Pneumoperitoneum group	T_1	7.40 ± 0.12	462 ± 138	36.3 ± 4.1
	T_2	7.38 ± 0.18	382 ± 146*,#	45.2 ± 2.9*
	T_3	7.35 ± 0.24	387 ± 169*,#	46.7 ± 3.8*
	T_4	7.34 ± 0.19	469 ± 126	40.8 ± 2.3

Footnote: 1 cmH_2O = 0.098 kPa; *compared with the data at T_1 in the same group, P < 0.05; #compared with the data at the same time point in NP group, P < 0.05.

Table 5. Comparison of perioperative serum cortisol, IL-6 and TNF-α levels in the two groups (n = 20, pg/L)

Groups	Time points	Serum cortisol	IL-6	TNF-α
Nonpneumoperitoneum group	T_1	315.4 ± 79.2	19.1 ± 7.8	17.8 ± 9.3
	T_2	408.4 ± 80.2*	24.3 ± 8.5	23.5 ± 8.4
	T_3	481.5 ± 79.6#	29.5 ± 8.9*	28.4 ± 9.6*
	T_4	521.8 ± 95.8#	32.6 ± 7.8*	35.7 ± 7.6#
Pneumoperitoneum group	T_1	314.8 ± 78.9	18.2 ± 6.9	18.2 ± 10.3
	T_2	482.3 ± 79.4*,&	31.2 ± 7.9*,&	30.4 ± 10.9*
	T_3	534.7 ± 82.2#,&	35.2 ± 8.1#,&	36.4 ± 11.7#,&
	T_4	604.0 ± 92.5#,&	39.6 ± 6.5#,&	48.3 ± 9.6#,&

Footnote: 1 cmH_2O = 0.098 kPa; compared with the data at T_1 in the same group, *P < 0.05, #P < 0.01; compared with the data at the same time point in NP group: &P < 0.05.

nificant (P > 0.05). As for the patients of P group, p_aO_2 at T_2 and T_3 were significantly lower than that at T_1 and those at the same time point in NP group (P < 0.05), and p_aCO_2 at T_2 and T_3 were significantly higher than those at T_1 (P < 0.05). See **Table 4**.

Perioperative serum cortisol, IL-6 and TNF-α levels

The serum cortisol, IL-6 and TNF-α level of the patients of both groups gradually increased as the surgery was conducted. In NP group, the serum cortisol level at T_2, T_3 and T_4 and the levels of IL-6 and TNF-α at T_3 and T_4 were all remarkable higher than those at T_1 (P < 0.05, P < 0.01, respectively). In P group, the serum cortisol level at T_2, T_3 and T_4 were all significantly higher than those at T_1 (P < 0.05), and the serum cortisol level at T_3 and T_4 were all significantly higher than those at the same time points in NP group (P < 0.05). Meanwhile, in P group, the levels of IL-6 and TNF-α at T_2, T_3 and T_4 were all significantly higher than those at T_1 (P < 0.01) and those at the same time points in NP group (P < 0.05). See **Table 5**.

Discussion

Traditional laparoscopic surgeries mainly adopt CO_2 as the medium in pneumoperitoneum, but CO_2 has an obvious impact on the respiratory and circulatory system and the degree of influence was closely associated with IAP, ventilation duration, conditions of the patients and surgical position [7-9]. Trendelenburg position taken in gynecological surgery would cause a further elevation of the patient's diaphragm, pressure on pulmonary at the bottom, increase of airway resistance and decrease of chest and lung compliance, and even results in ventilation/perfusion (V/Q) imbalance and ventilation dysfunction if there is a server influence [10]. This study showed that the chest and lung compliances and p_aO_2 at T_2 and T_3 were significantly lower than those at T_1, while Ppeak, Pplat and p_aCO_2 were significantly higher than those at T_1 in P group, however, no obvious changes were

observed in the indicators of the patients of NP group, which indicated that nonpneumoperitoneum had little effect on respiratory function. Moreover, CO_2 pneumoperitoneum would cause an increase of abdominal pressure to squeeze the venous blood of the abdominal cavity into the thoracic cavity, thus increasing returned blood volume, which was combined with the impact of intrathoracic pressure increase to cause an elevation in CVP [11]. This study found that CVP in the patients of P group increased significantly after pneumoperitoneum, and was significantly higher than that at the same time points in the patients of NP group.

Cortisol is a sensitive indicator reflecting the stress response of the body, and the cytokine IL-6 and TNF-α can act on the hypothalamus-pituitary-adrenal axis (HPA axis) and stimulate ACTH and cortisol secretion to cause cascade reaction and aggravate stress stimulation [12]. In this study, the changes in serum IL-6 and TNF-α level were similar to the trend of serum cortisol level, suggesting that stress stimulation can activate HPA axis by cytokines and some immunologically active substances secreted by immune cells to cause an increase of serum cortisol level. The stress stimuli of minimally invasive laparoscopic surgery was mainly from CO_2 pneumoperitoneum, of which the extent was related to that of the elevation of p_aCO_2, that is, the longer pneumoperitoneum duration was and the higher p_aCO_2 was, the stronger the stress response was [13]. In this study, the levels of serum cortisol, IL-6 and TNF-α in P group were significantly higher than those in NP group, which was consistent with the results from the study in which laparoscopic cholecystectomy was performed by Larsen et al. [13], indicating a slight stress response in NP group.

The results from this study showed that a shorter recovery time of borborygmus and lower incidence of postoperative nausea, vomiting and shoulder pain in the patients of NP group may be attributed to IAP elevation and hypercapnia caused by CO_2 pneumoperitoneum, which, on the one hand, stimulate the mechanoreceptors and chemoreceptors of the gastrointestinal tract to increase the excitability of afferent vagus nerve and excite the vomiting center, thereby causing nausea, vomiting and prolongation of recovery time of borborygmus [14], and on the other hand, cause that the phrenic nerve is pulled and stimulated, resulting in aggravated shoulder pain [15].

There are certain limitations that should be addressed. The size of sample is just 40. However, it represents a least-biased attempt to pool the results. A prospective randomized trial is necessary to confirm our findings. Large randomized, double-blinded, multicentre, controlled clinical trials, which compare non-pneumoperitoneum laparoscope and pneumoperitoneum laparoscope in gynecological geriatrics, will be even better.

During the gynecological surgery in elderly patients, gasless laparoscopy has the advantages including less impact on respiratory and circulatory system function, slight stress response, rapid recovery of borborygmus, lower incidence of postoperative nausea, vomiting and shoulder pain, etc., and is conducive to the rehabilitation of the patients.

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Disclosure of conflict of interest

None.

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References

[1] Zhu Q, Mao Z, Jin J, Deng Y, Zheng M and Yu B. The safety of CO_2 pneumoperitoneum for elderly patients during laparoscopic colorectal surgery. Surg Laparosc Endosc Percutan Tech 2010; 20: 54-57.

[2] Andersson LE, Baath M, Thorne A, Aspelin P and Odeberg-Wernerman S. Effect of carbon dioxide pneumoperitoneum on development of atelectasis during anesthesia, examined by spiral computed tomography. Anesthesiology 2005; 102: 293-299.

[3] Odeberg-Wernerman S. Laparoscopic surgery--effects on circulatory and respiratory physiology: an overview. Eur J Surg Suppl 2000; 4-11.

[4] Wang Y, Cui H, Zhao Y and Wang ZQ. Gasless laparoscopy for benign gynecological diseases using an abdominal wall-lifting system. J Zhejiang Univ Sci B 2009; 10: 805-812.

[5] Uen YH, Chen Y, Kuo CY, Wen KC and Koay LB. Randomized trial of low-pressure carbon dioxide-elicited pneumoperitoneum versus abdominal wall lifting for laparoscopic cholecystectomy. J Chin Med Assoc 2007; 70: 324-330.
[6] Wang JJ, Yang F, Gao T, Li L, Xia H and Li HF. Gasless laparoscopy versus conventional laparoscopy in uterine myomectomy: a single-centre randomized trial. J Int Med Res 2011; 39: 172-178.
[7] Nesek-Adam V, Mrsic V, Smiljanic A, Oberhofer D and Grizelj-Stojcic E. [Pathophysiologic effects of CO2-pneumoperitoneum in laparoscopic surgery]. Acta Med Croatica 2007; 61: 165-170.
[8] Meininger D, Zwissler B, Byhahn C, Probst M, Westphal K and Bremerich DH. Impact of overweight and pneumoperitoneum on hemodynamics and oxygenation during prolonged laparoscopic surgery. World J Surg 2006; 30: 520-526.
[9] Uzunkoy A, Ozgonul A, Ceylan E and Gencer M. The effects of isothermic and hypothermic carbon dioxide pneumoperitoneum on respiratory function test results. J Hepatobiliary Pancreat Surg 2006; 13: 567-570.
[10] Suh MK, Seong KW, Jung SH and Kim SS. The effect of pneumoperitoneum and Trendelenburg position on respiratory mechanics during pelviscopic surgery. Korean J Anesthesiol 2010; 59: 329-334.
[11] Kamolpornwijit W, Iamtrirat P and Phupong V. Cardiac and hemodynamic changes during carbon dioxide pneumoperitoneum for laparoscopic gynecologic surgery in Rajavithi Hospital. J Med Assoc Thai 2008; 91: 603-607.
[12] Frank MG, Watkins LR and Maier SF. Stress-induced glucocorticoids as a neuroendocrine alarm signal of danger. Brain Behav Immun 2013; 33: 1-6.
[13] Larsen JF, Ejstrud P, Svendsen F, Pedersen V and Redke F. Systemic response in patients undergoing laparoscopic cholecystectomy using gasless or carbon dioxide pneumoperitoneum: a randomized study. J Gastrointest Surg 2002; 6: 582-586.
[14] Koivusalo AM, Kellokumpu I and Lindgren L. Gasless laparoscopic cholecystectomy: comparison of postoperative recovery with conventional technique. Br J Anaesth 1996; 77: 576-580.
[15] Mouton WG, Bessell JR, Otten KT and Maddern GJ. Pain after laparoscopy. Surg Endosc 1999; 13: 445-448.