Indian J Surg (February 2018) 80(1):30–35
DOI 10.1007/s12262-016-1552-4

ORIGINAL ARTICLE

Comparing Hemodynamic Symptoms and the Level of Abdominal Pain in High- Versus Low-Pressure Carbon Dioxide in Patients Undergoing Laparoscopic Cholecystectomy

A. R. Mohammadzade[1,2] · **F. Esmaili**[1]

Received: 7 August 2016 / Accepted: 7 October 2016 / Published online: 28 October 2016

Abstract The laparoscopic cholecystectomy (LC) is the gold standard to treat gallstone. To view the surgical site in this type of operations better, carbon dioxide is used with a certain pressure. The current study aimed to compare the hemodynamic symptoms and the level of abdominal pain due to using high- and low-pressure carbon dioxide in patients undergoing LC. The current double-blind randomized clinical trial was conducted on 60 patients with the age range of 20–70 years old undergoing LC. The first and second groups experienced $PaCO_2$ of 7–10 and 12–14 mmHg, respectively. The hemodynamic symptoms, abdominal pain, shoulder-tip pain, nausea and vomiting after the surgery, and the mean of liver function tests were evaluated. Data were analyzed using *T* test, Chi-square test, and repeated measures ANOVA by SPSS 16. Information of 60 patients in two groups was analyzed. There was a significant difference between the groups regarding the mean of systolic blood pressure ($P < 0.05$). The mean of heart rate was significantly higher in the high-pressure group during surgery and 1 h after that ($P < 0.05$). The frequency of pain in shoulder-tip and abdomen was higher in the high-pressure group. Frequency of nausea and vomiting 12 h after the surgery between two groups was significant ($P < 0.05$). The mean of alkaline phosphatase was higher in the low-pressure group than the high-pressure group ($P < 0.05$). Considering the good performance and low side effects of low-pressure laparoscopic cholecystectomy compared to those of high-pressure, this method can be replaced by high-pressure in LC.

Keywords Laparoscopic cholecystectomy · Low-pressure pneumoperitoneum · High-pressure pneumoperitoneum · Gallstone

Introduction

The gallstone is a common complication of biliary tract, and since 1882 surgery is the best common traditional method to remove it [1, 2]. Almost 10 % of the population has gallstones, and cholecystectomy is the most common surgical method to treat it in the Western countries [1].

However, today, the laparoscopic cholecystectomy (LC) is the gold standard to treat gallstones. It was introduced by Dubois in 1988 and gradually developed by monitor and video systems [3]. It is about 20 years that LC is practiced in Iran. The following advantages of this surgical procedure have encouraged patients and surgeons toward it: short cuts, short hospital stay, less side-effects, lower post-surgery pain, rapid return to normal activities, and mortality less than 1 % [1, 2].

To obtain satisfactory results, the site of surgery should be clearly viewed during LC; pneumoperitoneum is one of these methods to provide this condition [4]. In this method, CO_2 enters the peritoneal cavity and the pressure kept constant up to the end of surgery, when the ports are removed [5]. The standard pressure in pneumoperitoneum is 12–14 mmHg; it is also associated with complications that usually happen following the prolonged and difficult surgeries due to head-down position and transmission of carbon dioxide to peritoneum (pneumoperitoneum); for example: reducing lung capacity, changes in the concentration of arterial blood gases, hemodynamic complications, increasing liver enzymes, renal failure,

✉ A. R. Mohammadzade
malireza34@yahoo.com

[1] Department of Surgery, Velayat Hospital, Qazvin University of Medical Sciences, Qazvin, Iran

[2] Velayat Clinical Research Development Unit, Velayat Hospital, 22 Bahman Blvd, P.O.BOX 34719-76161, Qazvin, Iran

and increasing post-operative intra-abdominal venous pressure [6–8].

Recently, to reduce the complications, surgeons tend to use gases with 7–10 mmHg pressure instead of the standard pressure. Using lower-pressure gases for the elderly and patients with chronic respiratory and cardiovascular diseases obtain good results. Less shoulder-tip pain and increasing the quality of life after the surgery are other advantages of this method. On the other hand, using lower-pressure gases limits clear viewing of surgical site, prolongs the surgery time, and increases the complications which may lead the surgeon to use standard pressure and open surgery [6, 7].

Considering the advantages of LC, the current study aimed to compare the hemodynamic symptoms and the level of abdominal pain due to using high- and low-pressure carbon dioxide in patients undergoing LC.

Methods

The current double-blind randomized clinical trial was conducted on 60 patients undergoing LC in Velayat Hospital affiliated to Qazvin University of Medical Sciences, Qazvin, Iran, in 2012. The age range of patients was 20–70 years old, and they were randomly categorized into 2 groups of 30. The exclusion criteria were as follows: rupture of gallbladder, empyema, common bile duct stones, patients undergoing extensive upper abdominal surgery, pregnant females, patients with body mass index (BMI) >30 and <19, fatty liver grade 3 and 4, and elevated liver enzymes before the surgery.

In the current study, the pneumoperitoneum with $PaCO_2$ of 7–10 and 12–14 mmHg were used in the first and second groups, respectively. The standard four-port method, the same surgical method, and general anesthesia were used in the two groups. The same anesthesia protocol was used in both groups. All subjects changed their position or moved, if they could, and started eating 12 h after the surgery. None of the subjects or nurses was aware of the group type.

Abdominal pain at the site of surgery and shoulder-tip pain were evaluated in both groups based on the verbal rating scale (VRS) within 1, 3, 6, 12, and 24 h after the surgery in a way that no pain = 0, moderate pain = 1, medium pain (need one dose of sedative) = 2, severe pain = 3, and intractable pain = 4. The level of nausea and vomiting were also recorded in the groups within 1, 3, 6, 12, and 24 h after the surgery in a way that no nausea and vomiting = 0, slight nausea and vomiting = 1, need for anti-nausea drug = 2, and intractable vomiting = 3. To evaluate the level of liver enzymes such as aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), and bilirubin (BIL), the blood samples were obtained from the patients before and 24 h after the surgery.

The level of arterial blood pressure, heart rate, and body temperature of the subjects were recorded during the surgery and 1, 3, and 6 h after the surgery. Data were collected based on the designed checklists and transferred into SPSS ver. 16. Data regarding quantitative measures and qualitative measures were analyzed by T test and Chi-square tests, respectively. To assess parameter changes in the groups before and after the injection, ANOVA and repeated measurement were used. The current study was registered in the Iranian Clinical Trial Registry (code number: IRCT2014121420309N1).

Results

In this study, information of 60 patients was analyzed. In the first group, 22 cases (73.3 %) were females and 8 cases (26.7 %) were males. In the second group, 29 cases (96.7 %) were females and 1 case (3.3 %) was male. According to the results of the current study, there was no significant difference regarding the age (39 ± 13.3 vs. 36.4 ± 15.8, $P = 0.493$), weight (68.6 ± 7.1 vs. 73.1 ± 8.1, $P = 0.143$), and height (161.2 ± 4.7 vs. 158.9 ± 7.9, $P = 0.181$) between the two groups of $PaCO_2$ of 7–10 mmHg and $PaCO_2$ of 12–14 mmHg ($P > 0.05$).

There was a significant difference regarding the mean systolic blood pressure at specific intervals between the two groups, comparing the hemodynamic symptoms using repeated measured ANOVA ($P = 0.01$) (Fig. 1). On the other hand, there was no significant difference between the two groups comparing the mean diastolic blood pressure at specific intervals ($P = 0.08$); the means were similar in both groups (Fig. 2). There was a significant difference regarding the mean heart rates at specific intervals between the groups ($P = 0.001$), and the mean heart rate at specific intervals were not similar and the difference was obvious during the surgery and 1 h after the surgery (Fig. 3).

Results of the liver function tests showed a significant difference between the groups regarding all measured factors before and after the surgery, except that no significant difference was observed in the high-pressure group regarding the levels of BIL before and after the surgery. Accordingly, there was a significant difference between the two groups regarding the mean post-operation ALP after the surgery ($P = 0.03$); the means of other factors were similar in the two groups ($P = 0.03$) (Table 1).

The frequency of abdominal and shoulder-tip pain were compared between the two groups at 1, 3, 6, 12, and 24 h after the surgery using Chi-square test. According to the obtained results, there was no significant difference regarding the frequency of pain 1 h after the surgery between the groups; but significant differences were observed between the groups in other assessed time intervals, in a way that the pain grades 3

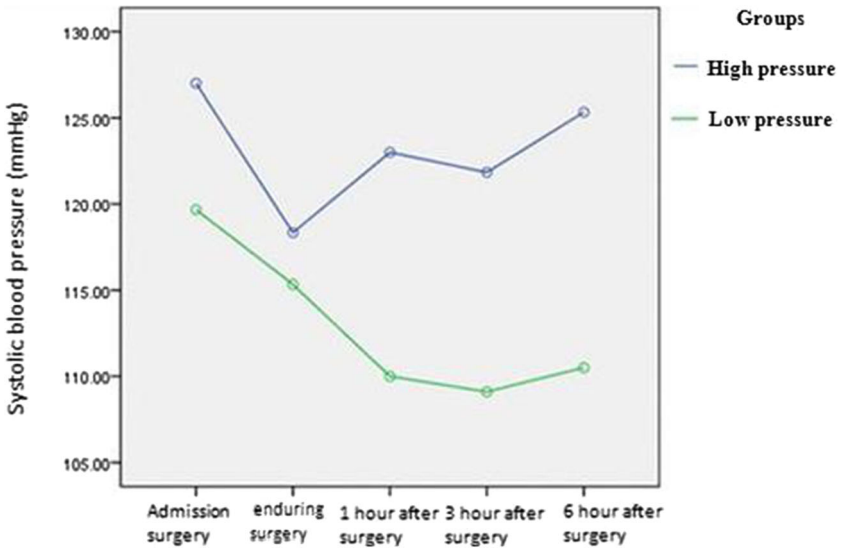

Fig. 1 Comparing the means of systolic blood pressure at specific intervals between two groups

and 4 were not observed in the low-pressure group at the assessed times (Table 2).

The frequencies of nausea and vomiting were compared between the groups at 1, 3, 6, 12, and 24 h after the surgery using Chi-square test. There was just a significant difference in this regard between the groups at 12 h after the surgery (Table 2).

Discussion

The current study compared the hemodynamic symptoms and the level of abdominal pain using low- and high-pressure carbon dioxide in patients undergoing LC. Results of the current study showed that subjects were similar in both groups regarding age, gender, and weight. There was a significant difference between the groups regarding the mean of systolic blood pressure and heart rate in the same time intervals, in a way that the means of the low-pressure group were lower than those of the high-pressure group ($P < 0.05$), but no significant difference was observed in the means of diastolic blood pressure between the two groups ($P = 0.08$). The frequencies of abdominal pain and shoulder-tip pain were lower in the low-pressure group, except the first hour after the surgery. There was a significant difference between the groups regarding the level of nausea and vomiting only 12 h after the surgery (0.01). Laparoscopy is a minimally invasive surgery which is nowadays preferred to open surgery. Laparoscopic surgeries are associated with better maintenance of hemostasis compared to open surgeries due to top benefits such as more rapid hospital discharge, less post-operative complications, and lower costs. Also, there is lower post-operative pain in laparoscopic surgeries compared to open ones. Laparoscopy is widely used in many surgeries; one of them is LC [9]. To perform a surgery with better results and avoid a second surgery, the surgical site should be viewed clearly; for better viewing the surgical site, CO_2 is used, in a way that the more CO_2 during the surgery, the better viewing the surgical site. But it is also associated

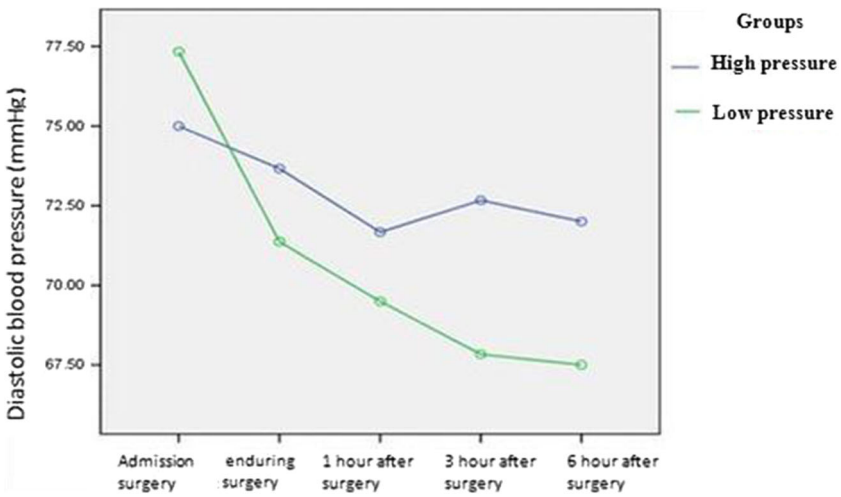

Fig. 2 Comparing the mean of diastolic blood pressure at specific intervals between the groups

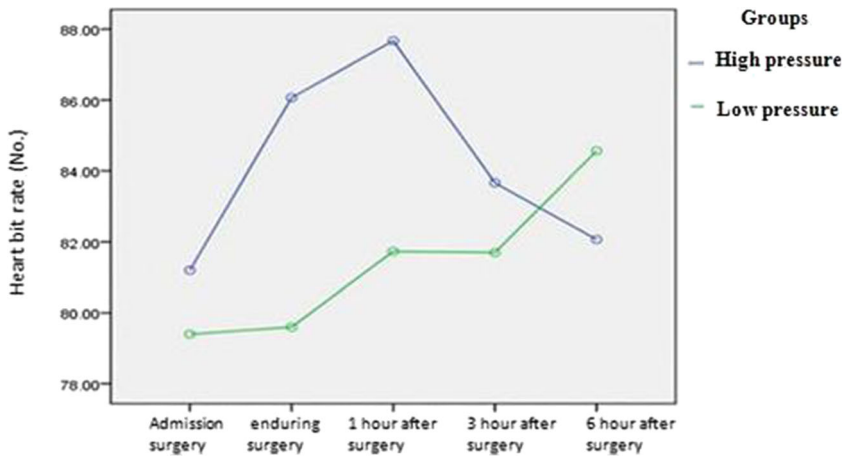

Fig. 3 Comparing the means of heart rate at specific intervals between the groups

with some complications, and accordingly several studies are conducted on using different CO_2 pressures during the surgery for better viewing the surgical site and fewer complications [10].

One of the common complications of laparoscopy is the hemodynamic changes during peritoneal insufflation of carbon dioxide associated with decreased cardiac output, increased systemic vascular resistance, hypertension, heart rate changes, reduced respiratory capacity, and increased airway pressure [11]. Detrex et al. compared the post-operative results obtained from surgeries with 15 and 7 mmHg $PaCo_2$. Accordingly, they reported that the decreased cardiac output, stroke volume of heart, and heart rate changes in the low-pressure group was much lower than those of the high-pressure group, and both groups had good surgical results. In another study, Kanwer et al. compared the results of two CO_2 pneumoperitoneum pressures, 10 and 14 mmHg, and reported no significant difference between the groups regarding the levels of systolic and diastolic blood pressures, heart rate, and pain, 6 h after the surgery, although the results were lower in the low-pressure group [11]. Although laparoscopy was a modern step toward the surgery quality improvement and lowering its complications, the pain in difficult surgeries still exists and a new step toward controlling the pain can satisfy the patients. Also, studies showed that in 17–41 % of the patients, the main cause of hospital discharge delay and longer hospitalization within the first 24 h after the surgery was the pain caused by LC, and accordingly the first and main complaint of the patients is about prolonged hospitalization due to LC [12, 13]. In the study by Vesakis that compared the level of pain between the low-pressure and without pressure groups, there was no significant difference regarding the level of abdominal pain between the groups; but because of prolonged surgery, the shoulder-tip pain was more in the high-pressure group [14]. In the current study, the levels of abdominal and shoulders-tip pain were higher in the high-pressure group, compared to the low-pressure one. In the study by Kanwer et al., they reported a significant difference regarding the level of 12 h post-operative pain between the groups; it was lower in the low-pressure group (54.2 ± 8.5 vs. 62.2 ± 12.0). In another study by Al–Dabbagh [10] on the level of post-operative pain in patients undergoing LC, patients were categorized in two groups as low-pressure of 8 mmHg and high-pressure of 12 mmHg. Comparing the post-operative pain between the groups showed that the level of 4, 8, 12, and 24 h post-operative pain in abdomen and shoulders were lower in the low-pressure group, and the significant difference was observed between them (P = 0.01)

Table 1 Comparing the mean and standard deviation of liver function test results, before and after the surgery in two groups

	High-pressure		*P* value	Low-pressure		*P* value	*P* value regarding the post-operative level of enzymes between two groups
	Post-operation	Pre-operation		Post-operation	Pre-operation		
AST	37.9 ± 13.3	20.6 ± 6.8	0.001	45 ± 29.1	20.8 ± 7.1	0.001*	0.23
ALT	31 ± 12.2	20.7 ± 13.7	0.001	34.9 ± 15.4	18.6 ± 6.7	0.001*	0.28
ALP	187 ± 78.2	185 ± 63	0.8	147 ± 61.2	169.7 ± 57	0.001*	0.03*
BILLT	0.7 ± 0.2	0.6 ± 0.3	0.008	0.66 ± 0.2	0.61 ± 0.16	0.01*	0.3
BILLD	0.3 ± 0.1	0.2 ± 0.1	0.03	0.3 ± 0.1	0.21 ± 0.05	0.002*	0.7

*P value < 0.05 was considered as the level of significance

Table 2 Comparing the frequency of subjects regarding abdominal pain, shoulder-tip pain, and the level of nausea and vomiting post-operative symptoms between two groups

Time after surgery	Adverse event	Pressure groups	Score				
			0	1	2	3	4
1 h	Shoulder-tip	Low	4	16	10	0	0
		High	2	8	16	4	0
	P value	0.03*					
	Abdominal	Low	0	4	20	6	0
		High	0	6	12	11	1
	P value	0.18					
	Nausea and vomiting	Low	8	12	6	4	–
		High	5	10	14	1	–
	P value	0.1					
3 h	Shoulder tip	Low	14	12	4	0	0
		High	2	11	13	4	0
	P value	0.03*					
	Abdominal	Low	0	8	22	0	0
		High	0	1	19	9	1
	P value	0.001*					
	Nausea and vomiting	Low	10	12	8	0	–
		High	8	11	10	1	–
	P value	0.6					
6 h	Shoulder tip	Low	10	12	8	0	0
		High	4	10	10	6	0
	P value	0.03*					
	Abdominal	Low	0	16	14	0	0
		High	0	8	17	4	1
	P value	0.04*					
	Nausea and vomiting	Low	16	8	6	0	–
		High	11	10	8	1	–
	P value	0.4					
12 h	Shoulder tip	Low	20	10	0	0	0
		High	10	8	12	1	0
	P value	0.001*					
	Abdominal	Low	4	4	22	0	0
		High	0	0	7	22	1
	P value	0.001*					
	Nausea and vomiting	Low	22	2	6	0	–
		High	7	18	4	1	–
	P value	0.001*					
24 h	Shoulder tip	Low	22	8	0	0	0
		High	16	9	6	0	0
	P value	0.02*					
	Abdominal	Low	8	22	0	0	0
		High	0	24	6	0	0
	P value	0.001*					
	Nausea and vomiting	Low	26	4	0	0	–
		High	21	8	1	0	–
	P value	0.23					

*P value < 0.05 was considered as the level of significance

[15]; the results of their study are compatible with those of the current study.

Increasing the level of liver enzymes is one of the complications associated with LC evaluated in some studies; in a study by Sayadi et al. on the effect of low- and high-pressure carbon dioxide, compared with open surgery based on the increased liver enzymes, the results showed a significant difference between the first and second groups regarding changing the level of liver enzymes before and after the surgery, but the changes were transient and the rates dropped by passing the time. But in the third group, the changes in AST and ALT were significant only before and 24 h after the surgery and the high rates dropped to initial level after 72 h. However, there was also a significant difference between the first and second groups regarding the level of lactate dehydrogenase (LDH) before and 24 h after the surgery [16]. In the study by Hasuki, the level of increased liver enzymes were compared between the groups of $PaCO_2$ of 14 and 7 mmHg gas pressure; result of his study indicated that the levels of liver enzymes were significantly higher in the high-pressure group 24 h after the surgery compared with those of the low-pressure group and the rates dropped to the initial level after 48 h [17].

In the current study, the means of liver enzymes after the surgery were higher than those of before surgery in both groups. There was a significant difference regarding the level of ALP between the groups; the mean was lower in the low-pressure group, but according to Sayadi the difference was observed in the level of LDH.

Conclusion

Considering the advantages of laparoscopy and also the necessity for peritoneal CO_2 insufflation for better viewing the surgical site, results showed that using low-pressure CO_2 decreases hemodynamic complications and also the levels of abdominal and shoulder-tip pains in patients compared to those of the high-pressure CO_2.

Acknowledgments Authors of this paper are thankful for the valuable cooperation of the Clinical Research Development Unit of Velayat hospital in Qazvin province, Iran.

Compliance with Ethical Standards

Ethical Statement The current study was registered in the Iranian Clinical Trial Registry (code number: IRCT2014121420309N1).

Funding This report received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Johansson M, Thune A, Blomqvist A et al (2003) Management of acute cholecystitis in the laparoscopic era: results of a prospective, randomized clinical trial. J GastrointestSurg 7(5):642
2. Van Der Linden W, Edlund G (1981) Early versus delayed cholecystectomy: the effect of a change in management. Br J Surg 68(11):753–757. doi:10.1002/bjs.1800681102
3. Brunicardi CF, Andersen DK, Billiar TR et al (2005) Schwartz's principles of surgery. Vol 2. 8th ed. McGraw Hill, New York, pp. 1194–1204
4. Uen YH, Chen Y, Kuo CY et al (2007) Randomized trial of low pressure carbon dioxide elicited pneumoperitoneum versus abdominal wall lifting for laparoscopic cholecystectomy. J Chin Med Assoc 70:324–330. doi:10.1016/S1726-4901(08)70013-3
5. Chok KS, Yuen WK, Lau H et al (2006) Prospective randomized trial on low pressure versus standard pressure pneumoperitoneum in outpatient laparoscopic cholecystectomy. SurgLaparoscEndoscPercutan Tech 16:383–386. doi:10.1097/01.sle.0000213748.00525.1e
6. Koc M, Ertan T, Tez M et al (2005) Randomized prospective comparison of postoperative pain in lowversus- high pressure pneumoperitoneum. ANZ J Surg 75:693–696. doi:10.1111/j.1445-2197.2005.03496.x
7. Esmat ME, Elsebae MM, Nasr MM et al (2006) Combined low pressure pneumoperitoneum and intraperitoneal infusion of normal saline for reducing shoulder tip pain following laparoscopic cholecystectomy. World J Surg 30:1969–1973
8. Catani M, Guerricchio R, De Milito R et al (2004) "Low-pressure" laparoscopic cholecystectomy in high risk patients (ASA III and IV): our experience. Chir Ital 56(1):71–80
9. Joris J, Cigarini I, Legrand M et al (1992) Metabolic and respiratory changes after cholecystectomy performed via laparotomy or laparoscopy. Br J Anaesth 63:341–345. doi:10.1093/bja/69.4.341
10. Baraka A, Jabbour S, Hammond R et al (1994) End tidal carbon dioxide tension during laparoscopic cholecystectomy. Anaesthesia 49:403–406. doi:10.1111/j.1365-2044..tb14178.x
11. Kanwer DB, Kaman L, Nedounsejiane M et al (2009) Comparative study of low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy—a randomised controlled trial. Trop Gastroenterol 30(3):171–174
12. Pakravan M, Roshani M, Yazdani S et al (2012) Pregabalin and gabapentin for postphotorefractive keratectomy pain: a randomized controlled trial. Eur J Ophthalmol 22(Suppl 7):S106–S113. doi:10.5301/ejo.5000143
13. Imani F, Nezafati M, Heidarian M et al (2012) Effect of single dose premedication with pregabaline on pain after minor surgery(Persian). J Anesth Pain 2(8):180–185
14. Vezakis A, Davides D, Gibson JS et al (1999) Randomized comparison between low-pressure laparoscopic cholecystectomy and gasless laparoscopic cholecystectomy. SrugEndosc 13(9):890–893. doi:10.1007/s004649901127
15. Al-Dabbagh A, Ismaeel NH (2010) Randomized, prospective comparison of post-operative pain in low- versus high-pressure pneumoperitoneum in laparoscopic cholecystectomy. Zanco J Med Sci 14(2):35–40 http://www.zjms-hmu.org/files/articles/280211014423.pdf
16. Sayadi S, Ebrahimi M, Khalilian A et al (2013) Effect of different carbon dioxide pressure on liver enzyme in laparoscopic cholecystectomy and open cholecystectomy. J MazandaranUniv Med Sci 23(98):92–96
17. Hasukiæ S (2005) Postoperative changes in liver function tests: randomized comparisons of low and high pressure laparoscopic cholecystectomy. SurgEndosc 19:1451–1455