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Hemodynamic Response to Laparoscopic Cholecystectomy – Impacts of Increased Afterload and Ischemic Dysfunction of the Left Ventricle

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Summary

The authors describe the results of intra-operative hemodynamic monitoring during laparoscopic cholecystectomy in patients with ischemic left ventricular dysfunction and with significant aortic stenosis. The results in the groups composed of 13 and 12 patients were compared with the findings in 10 young, non-obese, non-smokers without significant cardiovascular history and with normal findings during resting transthoracic echocardiography. Monitoring itself was conducted using transesophageal echocardiography 1) after the induction of anesthesia, 2) after the induction of capnoperitoneum, and 3) after setting the operative anti-Trendelenburg position. The measurements were performed at least in triplicate and the results were processed using ANOVA test. Significant differences were identified in the time course patterns of heart rate, mean arterial pressure, dual product (pressure-rate-product), and cardiac output. In terms of pathophysiology, we believe that the most important achievement was the identification of different time course patterns of individual parameters in the respective groups. The results in the group of patients with aortic stenosis were based particularly on the different time course of the mean arterial pressure, while the results in patients with ischemic disease were more dependent on the time course of the heart rate. Very ineteresting is a drop of peripheral vascular resistance after positioning of these patients which could be explained only partially by a beta-blocking or ACEI medication. In clinical terms, the most important finding was probably that no complications occurred in the entire group of 35 patients, of which 25 suffered from severe organic cardiopathies.

Key words

Laparoscopic cholecystectomy • Hemodynamic response in cardiac patients • Transesophageal echocardiography

Introduction

The risk of non-cardiac surgical interventions in cardiac patients is elevated compared to the general population and increases further with aging, the degree of functional restrictions according to NYHA (New York

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Heart Association *Classification*) or CCS (Canadian Cardiac Society *Classification*), the presence of manifest cardiac failure, arrhythmias or diseases of other vital organs (the kidneys, CNS, or lungs). In addition, the risk is influenced by the extent and site of the surgery.

In addition to the underlying factors, such as peri-operative mental stress (Tolksdorf 1985) or depressive symptoms caused by a long-term stay outside the home, the basic risks (even in non-cardiac patients) include the following: a) risks related to anesthesia; b) risks of the surgical procedure itself and the risk of the general response of the patient and c) the risk of long-term immobilization after the surgery.

Laparoscopic techniques in abdominal surgery currently require the combination of inhaled and intravenous anesthetics and the necessity of ensuring the respiratory tract by tracheal intubation. The use of epidural anesthesia, though controversial to a certain extent in cardiac patients (Bromage 1978), and local anesthesia combined with a neuroleptanalgesia are virtually impossible after the pneumoperitoneum had been introduced.

A laparoscopic approach to a surgical procedure has both benefits and disadvantages for a patient with organic cardiopathy. When comparing conventional and laparoscopic approaches, we should compare their influence on the spectrum of basic indicators, including: 1. operative risk, 2. wound healing, 3. pain, 4. extent and response of the acute phase, 5. risk of perioperative thromboembolism, 6. impact on the motility of the GIT, 7. post-operative comfort, 8. duration of the hospitalization, 9. length of the subsequent inaptibility and 10. long-term effect of the surgery .

Some parameters (such as the long-term outcome of surgery) are barely comparable, given, *inter alia*, the relatively short clinical experience with laparoscopic procedures (Demes *et al.* 2001). Many parameters suggest a superiority of laparoscopic methods – such as length of hospitalization and incapacity to work, reduced pain response, reduced number of early complications and the minimal negative effects on the motility of the GIT. According to Delaunay (1995), rapid restoration of muscular cardiorespiratory performance is crucial for a prevention of many complications.

We have adapted the complexity of the issue according to Rosenthal and Friedman (1998) using the example of a laparoscopic cholecystectomy, which ranks among the most common laparoscopic procedures.

Table 1. Comparison of laparoscopic and open cholecystectomy

Parameter surgery	Laparoscopy	Open
Length of surgery	↓	↑
Size of incision	↓	↑
Visceral retraction	↓	↑
Tissue destruction	↓	↑
Peritoneal tension	↑	↓
Intra-abdominal pressure	↑	↓
CO_2, acidosis	+	–

Comparison of several parameters of laparoscopic and conventional surgery (↑ extends, increases; ↓ shortens, reduces; **+** induces; **-** does not induce)

Laparoscopy is obviously a safe procedure. Meta-analysis of studies that covered over 200 000 patients who underwent laparoscopic surgery, shows a peri-operative mortality of l/2000 and severe peri-operative morbidity (defined as the necessity for re-operation or conversion to a laparotomic procedure) with a frequency of l/660. The incidence of life-threatening complications is thus much lower than during open surgery; however, the percentage of cardiac complications is comparable; these states represent one third of all complications (Nord 1992).

Laparoscopic procedures are based on some conditions. Any examination or action in the abdominal cavity requires the separation of certain structures, in particular of the abdominal wall. This is usually achieved by insufflating the abdominal cavity with a gas. Carbon dioxide (CO_2) is the most suitable medium despite several disadvantages. Although pressure values of 8-12 mm Hg in the peritoneal cavity (primarily accomplished by application of 3-5 liters of CO_2) are relatively low, this results primarily in the separation of anterior and lateral abdominal walls from the intra-abdominal organs and to a small extent in the separation of the organs as well (Ishizaki *et al.* 1993). This method alone is not sufficient to obtain a good approach to the peritoneal cavity. Therefore, the positioning of the patient is of great importance, in particular the inclination of the body in the direction away from the area being operated on. Elevation of the head and chest or even a half-sitting position is suitable for access to the sub-hepatic or sub-phrenic regions. A reduction of venous return and mean arterial pressure results from this position. Hence, the changes caused by the capnoperitoneum (with the pressure less than 10 mm Hg) are, to a certain extent, "neutralized" by the head upright position. Experimental data obtained in animal models show that the final changes are non-significant (Rosenthal and Friedman 1998).

Notions that introduction of pneumoperitoneum could be a burden exceeding physiological limits has been empirically accepted ever since laparoscopic techniques first began to be used. As most laparoscopic operations were initially performed by gynecologists in young females without any cardiac disease, this problem was supposed to be unimportant. However, nowadays situation is completely different, as the age of patients has shifted to higher categories – for example the work of Safrana *et al.* (1994) covered, according to the meta-analysis, 35 American hospitals in the 1990s, wherein one third of all patients undergoing laparoscopic surgery was older than 55, one quarter older than 65 and almost 10 % older than 75 years. Statistics show a high incidence of coronary artery disease (CAD) in these patients. Hence, the importance of hemodynamic and cardiorespiratory changes during the insufflation of the pneumoperitoneum in these patients is considerable.

Unlike supposed mild influence of an increased CO_2 levels in the blood, the filling of abdominal cavity followed by the transmission of pressure into chest cavity affects undoubtedly cardiac functions. In fact, the situation is even more complex and the data in literature are in many cases significantly different (Delaunay *et al.* 1995, Wahba *et al.* 1995, Alijani *et al.* 2004). Perhaps the only parameter which is agreed upon in most works is elevated blood pressure (McKenzie *et al.* 1980, Odeberg *et al.* 1994, Hodgson *et al.* 1970). Other cardiovascular parameters vary significantly depending on the pressure used in the pneumoperitoneum or capnoperitoneum. When using pressures of 20 mm Hg and more, insufflation of the capnoperitoneum leads to a significant reduction of the venous return. This results in a reduction of the central venous pressure (CVP) and cardiac output. Currently, physicians tend to use the lowest possible intra-abdominal pressures. In such cases, venous return is increased after the insufflation of the peritoneum, probably due to mobilization of blood pooled in the splanchnic region (Odeberg *et al.* 1994).

The elevation of the mean arterial blood pressure (MAP) is caused, according to many authors (Dexter *et al.* 1999, Lenz *et al.* 1976), by an increase of systemic peripheral vascular resistance (PVR). This elevation of the afterload is considered to be the main risk factor for patients with reduced functional reserve of the left. The increased afterload seems to play a greater role in the tendency to decrease cardiac output than the reduced venous return. Cardiovascular functions are affected in many ways during laparoscopic surgery; we can find many contradictory tendencies – such as a significant tendency for hypotension induced by an intravenous administration of an anesthetic drug, acting against the tendency for the elevation of blood pressure after the insufflation of the pneumoperitoneum. However, the resulting clinical picture is further modified by many compensatory mechanisms. As throughout the entire field of cardiology, compensatory mechanisms are beneficial only to a limited extent. After exceeding some limits, such mechanisms can become a cause for the deterioration of the general circulation; this particularly happens if the mechanisms disproportionately increase myocardial energy requirements.

In addition to the progression of a cardiac disease and the degree of functional limitation, the final risk depends also on the type of cardiopathy. Aortic stenosis without severe regurgitation and without concurrent coronary disease is a typical model of cardiopathy resulting in a chronic pressure overload. The basic compensation mechanism is a development of left ventricular hypertrophy followed by subendocardial ischemia. Gradually, the imbalance between the afterload and preload is manifested in inability of the left ventricle to keep normal stroke volume and subsequently the cardiac output, irrespective of the maximum use of the ventricular filling at the end of diastole. These parameters typically cannot increase during exertion, and the volume of blood expelled to the circulation is thus limited by the capacity of flow through the narrowed artery. In this phase, there is a drop of ejection fraction in spite of normal contractility. Therefore, a rapid restitution of the left ventricular systolic function occurs after the surgery. The next phase, in which a "real" decrease of the left ventricular contractility occurs, is manifested as a reduced pressure gradient. In clinical terms, this is a terminal phase of the disease. An issue which is not clear in the literature (Gorscan *et al.* 1997, 1998) concern the indications for dobutamine echocardiography to distinguish the degree of progression of aortic stenosis and the probability of restitution of the ventricular ejection fraction after successful surgery. In terms of pathophysiology, it seems an appropriate method, however, it poses certain clinical risks.

The issue of the disorders of left ventricular contractility in ischemic heart disease, is even more complex. The identification of the sequence of events during myocardial ischemia (ischemic cascade) (Hoffmann and Sclafani 2000) contributed considerably to the clarification of this issue. The relaxation capacity of the left ventricle is the most vulnerable link, therefore a disorder of the systolic function does not occur before a disorder of the diastolic function. The next phase involves ECG manifestations and eventually ischemic pain. Ischemic disorder of the left ventricular function usually exhibits four phases: 1. Reduced pulmonary pressure; 2. Reduced ejection fraction and increased pulmonary pressure; 3. Reduced cardiac output; 4. Reduced systemic pressure with further progression thereof.

Methods

For the peri-operative monitoring of patients, echocardiography was chosen with a modification using a transesophageal probe as a method which provides many advantages. Transesophageal echocardiography (TEE) is a safe method. It is a semi-invasive method; the discomfort experienced by the patient is eliminated during a peri-operative modification under general anesthesia. The probability of esophageal perforation, the most serious complication of the method, is small. The incidence of this complication in gastrointestinal groups is reported to be 0.02-0.03 %. However, this can differ in patients with suspected esophageal pathology (Overholt *et al.* 1987). In our group, we investigated the presence, if any, of esophageal disorders in the patient´s medical history in accordance with the usual procedure. Other complications of TEE reported in the literature include: transient disorders of the heart rhythm, vomiting with risk of aspiration and bronchospasm. The latter is practically eliminated by the management of airways using endotracheal intubation. From the practical point of view, the surgery ward meets the requirement for cardiopulmonary resuscitation (both in terms of technical equipment and personnel skills). The risk of thermal damage is not relevant when using electronic probes and, in addition, the probe of our device (see below) is equipped with a heat sensor (Gussenhoven *et al.* 1986).

We used a Hewlett-Packard – Sonos 5500 and Image Point with an omniplanar esophageal probe for the echocardiographic examinations. We did not perform our examinations unless we obtained prior approval of the project from the ethical committee and the informed consent for the esophageal probe examination from each patient. The probe was introduced to the patient under anesthesia with the airways being bypassed by the endotracheal tube. The introduction of an esophageal echocardiographic probe in a mildly fixed ante-flexion was usually not difficult. When our attempt to introduce the probe was unsuccessful, the anesthesiologist was asked for assistance. In four cases, Magill forceps were required to introduce the probe. We did not encounter any complications during the examinations with the esophageal probe. The course of the examinations was recorded on videotape and the data were analyzed off-line. We compared three groups of measurements: 1) after the induction of anesthesia (“rest”), 2) after insufflation of the capnoperitoneum (“capno”) and 3) after setting into the position for surgery (“position”).

In each phase of measurement, we made at least three measurements and calculated the mean values.

In the initial phase of the examination, we determined the width of the outflow tract of the left ventricle. Pulse-Doppler examination of the outflow tract of the left ventricle and measurements of VTI (velocity time integral) were performed repeatedly in triplicate for each phase.

The heart rate (HR) was measured from a simultaneously recorded ECG; due to the routine monitoring of the ECG by the anesthesiologist, the curve from the three-lead monitoring system was displayed on the monitor of the echocardiograpic device.

The cardiac output (CO) was calculated according to the formula as follows: CO = πD2/4.VTI.HR (ml/min). The following formula was used for the calculation of peripheral resistance: PVR = (MAP.80)/CO.

The ejection fraction (EF) was determined using Simpson´s formula. And finally, for the monitoring of the transmitral flow, we measured the velocity of the E and A waves and calculated the appropriate indexes.

In addition, we monitored the so-called “double product” (Robinson 1967, Krska *et al.* 2004) which is referred to be “the pressure-rate product” (PRP) (Geigy Scientific Tables 1999). Another synonym is the Robinson index. From physiological point of view it is the product of systolic blood pressure and heart rate.

The hypothesis that ought to be tested by the statistical evaluation was, whether the time course pattern of the seven parameters to be examined (HR, EF, E/A index, CI, MAP, PVR, PRP) differed in the three different conditions among the three groups (control group, patients with IHD, and patients with aortic stenosis). As secondary objectives, we tried to answer the questions of whether the mean values of the parameters in all three conditions differed among the groups and whether the mean values of the parameters differed in the individual situations. For statistical evaluation, we used the analysis of variation (ANOVA) for a single classification factor (inclusion in the group of patients) and three repeated measurements in the three conditions (“rest”, “capno”, “position”) and one covariate (age).

10 patients without any history of cardiovascular disease, including arterial hypertension, who had normal physical findings, including normal blood pressure, and normal findings in common resting transthoracic echocardiography were enrolled in the first group called “norm”. These were 7 females and 3 men, with the average age of the entire group 36.8±11.2 years. The average age differed from the following two groups at the level of significance p=0.05.

The second group (hereinafter referred to as IHD) comprised patients with clinically relevant ischemic heart disease. To be included into this group, the patient had to have a history of coronary atherosclerosis confirmed by angiography or an indubitable history of myocardial infarction. Of the 13 patients in this group, 9 underwent re-vascularization of the myocardium (5x PTCA, 3x CABG, 1x both methods successively), so that the first “hard” requirement was met by most patients in this subgroup. The average age of the 7 males and 6 females was 65±10.4 years.

The third group consisted of patients with significant aortic stenosis or a combined defect with prevailing stenosis. Neither patients with significant left ventricular dysfunction nor those with concurrent coronary disease were included in this group. Also in this group averaging 70.1±6.5 years of age, males mildly outnumbered the females (8 vs. 4).

While the indications for laparoscopic cholecystectomy were symptomatic in the first two groups (cholecystolithiasis), patients with the aortic defect underwent the same preparation as for a scheduled cardiac valve replacement.

The first measurements were performed immediately after the induction of anesthesia and subsequent introduction of the gastroesophageal probe; the measurements obtained during this phase are referred to as “capno”.

Other measurements were performed after the setting of the operation table into the required operative position, which is always a semi-sitting position for cholecystectomy. Measurements obtained from the records acquired in this phase are referred to as “position”.

After the insufflation of the capnoperitoneum, examinations were made more easily without extending the total time of anesthesia due to esophageal monitoring. We were thus able to perform triplicate measurements at longer time intervals, immediately after the insufflation and later approx. 5 and 15 min thereafter. The measurements are referred to as “capno”.

Results

The results are summarized in Table 2, which shows the mean values and standard deviations for 7 parameters (HR, EF, E/A, CI, MAP, PRP a PVR) in 3 groups of people for 3 conditions consecutively during the operation.

The analysis of variance for the 7 parameters revealed different time course patterns of the means for the 3 measurements in 3 groups of subjects for the parameters HR, CI, PRP a MAP**.** No statistically significant differences in time course patterns of the means were found for the parameters EF, E/A, and PVR.

As for the heart rate and the product of heart rate and systolic blood pressure, the significant difference in the time course patterns for the 3 conditions in 3 groups of subjects was caused by the different response of cardiac patients with ischemic heart disease in comparison to two remaining groups, with the level of significance p=0.05 for the heart rate and (only) p=0.1 for the Robinson index.

Statistically significant (p=0.01) difference in the time course pattern of mean values of MAP for the 3 conditions in 3 groups of subjects was caused by the different response of the patients suffering from significant aortic stenosis and of the remaining two groups.

When investigating changes of the cardiac index with time, we have found a different time course in both groups of patients with organic heart disease on the one side and control group on the other. This difference was significant at the level of significance p=0.05.

Significantly different time course patterns of mean values of the hemodynamic parameters are shown in Figs. 1, 2, 3, 4 and 5 (standard deviations are in the Table 2).

Table 2. Overview of results in all parameters

Parameter	Group	N	Rest mean	Rest SD	Capno mean	Capno SD	Position mean	Position SD
HR	Norm	10	73.3	6.77	78.0	9.30	78.5	8.38
	cardiacs 1	13	70.6	11.42	75.2	10.75	67.8	10.62
	cardiacs 2	12	67.7	8.36	75.7	10.45	75.8	11.34
EF	Norm	10	64.5	9.48	64.2	5.31	63.5	5.58
	cardiacs 1	13	57.9	11.15	54.0	11.04	54.2	11.17
	cardiacs 2	12	65.4	10.35	63.2	10.80	62.2	9.59
E/A	Norm	10	2.03	0.80	1.83	0.70	1.92	0.74
	cardiacs 1	13	0.86	0.34	0.86	0.26	0.90	0.30
	cardiacs 2	12	0.68	0.33	0.72	0.27	0.87	0.41
CI	Norm	10	2.28	0.47	2.52	0.54	2.85	0.83
	cardiacs 1	13	3.21	0.75	3.21	0.72	3.17	0.80
	cardiacs 2	12	2.83	0.64	2.71	0.64	2.71	0.67
MAP	Norm	10	90.3	10.77	95.8	15.01	97.5	14.60
	cardiacs 1	13	97.3	8.99	98.6	21.05	91.3	14.47
	cardiacs 2	12	95.6	5.66	85.3	10.02	91.2	6.36
PVR	Norm	10	1847	627.2	1777	632.3	1642	575.8
	cardiacs 1	13	1460	446.5	1446	364.5	1392	492.0
	cardiacs 2	12	1555	370.0	1404	347.8	1508	293.1
PRP	Norm	10	8631	1577	9723	2300	9839	1691
	cardiacs 1	13	9713	2504	10347	2810	8780	2365
	cardiacs 2	12	8453	1301	8816	1257	9011	1567

(HR – heart rate, EF – ejection fraction, CI – cardiac index, MAP – mean arterial pressure, PVR – peripheral vascular resistance, PRP – pressure / rate product)

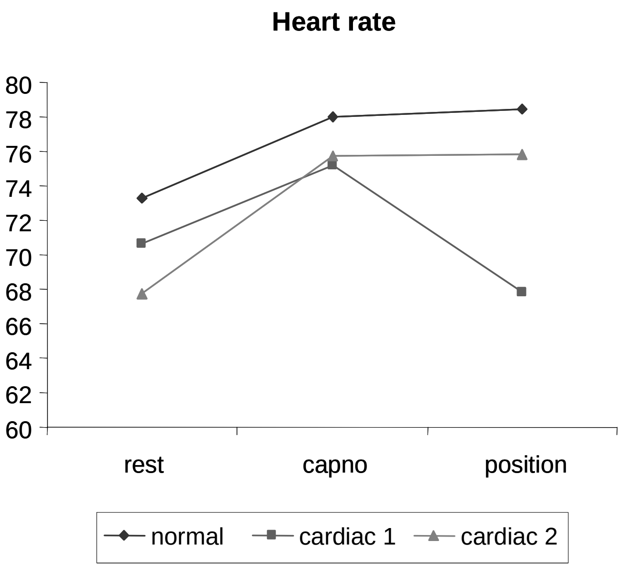

Fig. 1. Time course patterns of mean values of the heart rate in all three groups, p=0.01.

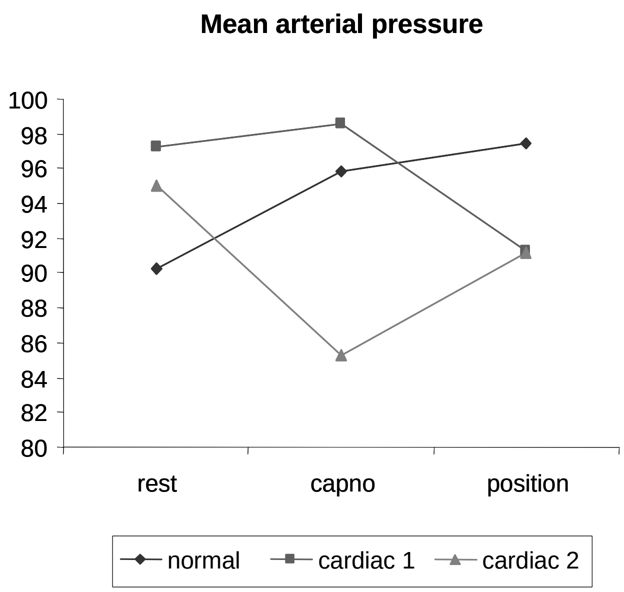

Fig. 2. Time course patterns of mean values of the mean arterial pressure in groups, p=0.01.

Discussion

Reliablity of results is based on the used method. TEE provides reliable results. When compared to invasive examination techniques requiring cannulation of the central vein, a very close correlation is reported, such as r=0.76-0.98 for the determination of cardiac minute output (Portera *et al.* 1995).

The results suggest that the differences in the time course patterns of the four parameters, in which such differences were identified (HR, MAP, CI, Robinson index), are caused by the different time course in one or the other group of patients with cardiopathy. The time course patterns of the parameters under investigation in the control group of patients without organic disease of the heart have been relatively uniform. The results are not surprising if considering that these parameters are determined by the heart rate and systemic blood pressure.

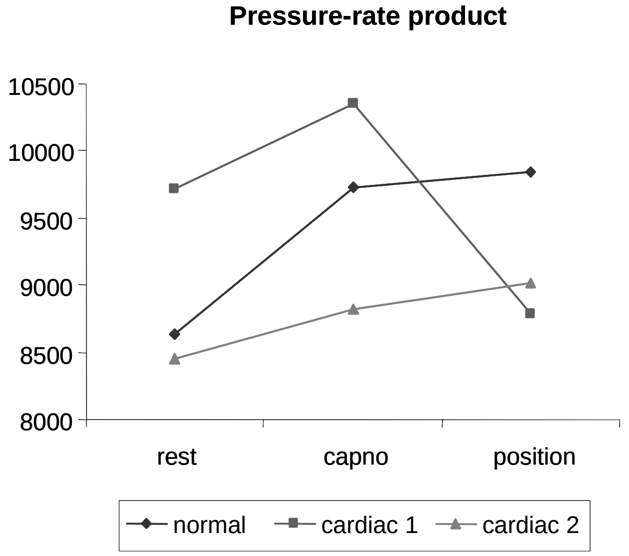

Fig. 4. Time course pattern of mean values of the pressure-rate product in all three groups, p=0.05.

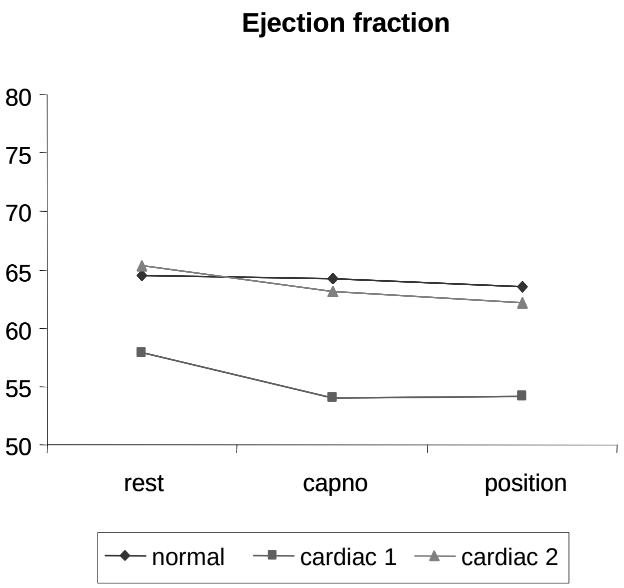

Fig. 3. Time course patterns of mean values of the ejection fraction in all three groups, p=0.01.

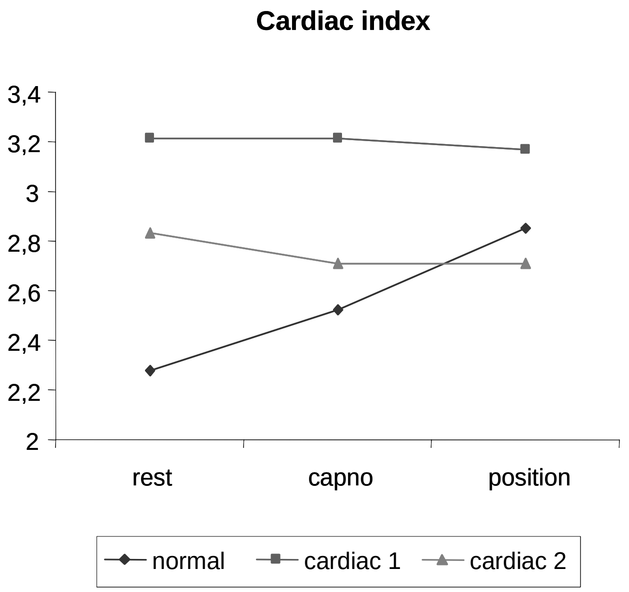

Fig. 5. Time course pattern of mean values of the cardiac index in all three groups, p=0.05.

In the control group, the heart rate and the mean arterial pressure increased after insufflation of the capnoperitoneum, while setting into the operative position suitable for the performance of laparoscopic cholecystectomy had no effect on the values. This is also not surprising since the Robinson index has a similar pattern of temporal dependence. The increase in the heart rate in the control group was probably the reason for the continual increase in cardiac output during the investigation, even in the event of a mild decrease in the left ventricular ejection fraction.

A statistically significant difference in the time course of heart rate was determined in particular by the decrease in heart rate after the setting into the operative position in a group of patients with ischemic heart disease. As the mean arterial pressure has a similar time course pattern, necessary chronic medication seems to be the most probable explanation in this group. While we intentionally enrolled patients without chronic medication influencing the heart rate and blood pressure into the group of patients with aortic stenosis (and this requirement was specified as *sine qua non* in the control group), the same requirement could not be met in the group of patients with ischemic heart disease. This would violate the principles of accepted clinical practice; in addition, all patients met the indication criteria for chronic administration of beta blockers or ACE inhibitors, 8 patients of the total of 13 used both groups of drugs *lege artis*.

Different time course pattern of the cardiac output or index, respectively, was dependent in particular on the decrease of the cardiac index in patients with an aortic defect. The mean value of the cardiac index in this group was lower even in the resting state, as we have supposed. The decrease after the induction of capnoperitoneum, and an even more profound decrease after setting the operative position confirms the well known fact, that a sufficient cardiac output is maintained only thanks to the increased contractile force and increased ejection pressure even in the resting state. Any additional load which leads to the development of tachycardia with a reduced diastole further disproportionately increases the energy requirements, with which the myocardium is unable to cope. The result is a markedly reduced functional reserve of patients with aortic stenosis.

Quite different is the situation of the time course pattern of the cardiac index in patients with IHD. The mean value of CI remains unchanged after induction of capnoperitoneum and then falls slightly after positioning of patients. As heart rate has its particular dynamics (see above) it can be concluded that there is an opposite time course of the stroke volume index (decrease after induction of captoperitoneum and significant increase after positioning). This development of the stroke volume after positioning of patients is most prabably due to increased preload as EF remains unchanged in these patients. Simultaneous increase of the stroke volume and decrease of the mean arterial pressure means a significant drop of peripheral vascular resistence after positioning of patients with IHD (see Table 2). This can be explained only partially by medication and the mechanism responsible for this phenomenon stays thus unclear.

Unlike several of our previous observations, in particular in patients with morbid obesity (Fried *et al.* 2001), our current observation of the three groups failed to confirm significant differences during the investigation of the time course patterns of transmitral flow. A difference was found even in the baseline values of the control group on the one hand, and both pathological groups on the other hand. In the first case, a completely normal ratio of velocity of E/A waves was found, while a considerably pathological ratio was found in the latter, which was conditional to the presence of a relaxation disorder in most patients. The pathologic character of the transmitral flow was even higher in patients with significant aortic stenosis. This finding fully corresponds with data in the literature on the hemodynamics of aortic stenosis (Safran and Orlando 1994). In particular, in the aortic stenosis group, one might perhaps expect an even more marked, i.e. statistically significant increase of the disorder during the surgery. We believe that a possible reason for this could be the fact that a mere observation of the Doppler transmitral flow curve is perhaps an inadequately sensitive parameter. Therefore, we introduced echocardiographic perioperative monitoring and detection of the character of the inflow from pulmonary veins in most patients. As we failed to examine the entire group in this manner, we report neither the results obtained, nor the sample size; irrespective of how unique was the sample size which highly exceeded all known reports dealing with the same issue, it was only slightly above the acceptable lower limit for statistical evaluation. We felt that a further decrease of the sample for statistical evaluation would be superfluous. However, we will focus on the Doppler examination of pulmonary veins in the future.

Finally, at the end of the discussion, we find it crucial that neither any life-threatening complication nor any forced treatment conversion had occurred during laparoscopic operation in 35 patients, of which 25 had clinically severe cardiopathy. The only cardiac complication concerned the development of bradycardia, which was managed using atropine.

We would like to point out that most operations were performed within 30-45 min of the duration of capnoperitoneum. During one of the two surgeries exceeding the upper limit of this interval, we observed a certain trend towards a decrease of the ejection fraction and cardiac output. However, this situation eventually did not require pharmacological intervention and after the completion of the surgery, the basic hemodynamic parameters rapidly recovered. The patients, including both groups of cardiac patients, could be extubated without complications even in the surgical theatre or in the post-surgery ward. All patients from the pathological groups were monitored for at least 24 hours at the intensive or intermediary care unit allowing continual ECG monitoring, pulse oxymetry and other basic functions. Furthermore, we recorded no major complication during this period and the patients were discharged on day 3 after the surgery.

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