CLINICAL STUDY

The significance of clinical markers in the prediction of hemodynamic and cardiac complications of capnoperitoneum in patients at risk

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Abstract

Objectives: **The aim of this prospective study was to find out the predictive value of concomitant diseases of cardiovascular system (CVS), lungs and kidneys as well as metabolic diseases to be able to anticipate the potential origin of hemodynamic and cardiopulmonary complications as a result of insufflated CO_2 peritoneum.**
Methods: **The study investigated eleven patients at the anaesthetic risk of ASA III-IV and cardiac risk of NYHA II-III in whom elective laparoscopic surgical intervention had been indicated.**
Results: **We have found out that the significance of the increase in biologic ANP markers, catecholamines and PRA was not sufficient to signal the deepening of cardiac dysfunction, latent cardiac failure or hemodynamic disorder ($p>0.01$). The courses of regression lines have shown the dependence on the increased IAP (intra-abdominal pressure) of capnoperitoneum in PRA and adrenaline. The reactions of biologic markers correlated with reactions of clinical hemodynamic markers of BP and HR. We have proved that the increased level of IAP causes a significant increase in CVP ($p<0.01$) being one of the factors determining the preload of right ventricle (RV) and in coincidence with intact transpulmonary circulation also the optimal function of left ventricle (LV).**
Conclusion: **Our investigation of peroperative clinical and biologic markers of hemodynamics and neuroendocrine response to operative stress and development of CO_2 peritoneum has proved that the course of laparoscopic operations in patients in the risk group of ASA III-IV and NYHA III does not necessarily have to be deteriorated by complications. It can be assumed that increased values of biologic markers regulate the neurohumoral response in the physiologic range and do not predict a severe CVS dysfunction within its course.** ***(Tab. 2, Fig. 3, Ref. 22.)***
Key words: intra-abdominal pressure, CO_2, pneumoperitoneum, hemodynamic disorder, biologic markers (ANP, PRA, catecholamines), clinical markers.

The principles of pathophysiological changes during pneumoperitoneum

Intra-abdominal pressure (IAP) increased by intra-peritoneal insufflation of carbon dioxide (CO_2) has serious abdominal as well as systemic effects and can represent the cause of organ dysfunction or failure. A significant organ dysfunction occurred already at IAP of 10 mmHg (13). Intra-abdominal hypertension (IAH) causes significant changes in almost all organ systems.

Abdominal insufflation in the range used in laparoscopic surgery causes an increase, rather than a decrease of venous return to the heart (20). This increase in venous return can result from the decreasing splanchnic capacity due to blood being pushed out of splanchnic veins. The increase in sympathetic activity is ascribed to the stimulation of chemoreceptors by increased pCO_2 observed in the course of CO_2 insufflation. The impact of sympathetic vasoconstriction mechanism was also considered to result from the movement of blood from the abdominal vascular reservoir toward the heart. Peritoneal insufflation leads to an increase in intra-abdominal pressure that assumingly

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Tab. 1. Unfavourable effects of IAH on CV functions and hemodynamics.

↓	Cardiac output and systemic ejection volume
↑↓	Venous return
↑	Systemic vascular resistance
↑	Pulmonary vascular resistance
↑	Afterload
↔	Pulmonary capillary pressure in block
↑	Median arterial pressure
↓	Flow within inferior vena cava and portalveins
↓	Arterial hepatic flow

IAH – intraabdominal hypertension, KV – cardiovascular, VCI – inferior vena

then increases the intra-thoracic pressure. This change in pressures within the cavities leads to complex hemodynamic metabolic, neurologic and humoral effects.

Many studies investigating cardiovascular changes associated with laparoscopic surgery have found an increase in systemic vascular resistance (SVR), median arterial pressure (MAP) and cardiac filling pressure documented by the impact of cardiac index (CI) with small changes in heart rate. The graduation of intra-abdominal pressure brought about a progressive decrease in cardiac output (CO) and an increase in systemic vascular resistance (5).

The concentration of renin and aldosterone in plasma of patients during laparoscopic cholecystectomy (LCHE) was observed to increase 4-fold (11). In addition to the latter there was also found a positive correlation between the increase in plasmatic renin activity and the increase in MAP in coincidence with CO_2 pneumoperitoneum (8). The increase in SVR and MAP can be expected due to the increase in catecholamines, however the time relation between the increase in catecholamines and the observed increase in SVR does not seem to be obvious. The increase in IAP from 10 mmHg to 20 mmHg is associated with an increase in concentrations of adrenaline and noradrenaline with no dependence on the used gas (CO_2, helium, N_2O) or the position of patient (10), however higher concentrations of circulating catecholamines were measured in patients during classic surgery, rather than during LCHE (4, 6). The summary of unfavourable effects of increased IAP is shown in Table 1.

Clinical differentiation of pneumoperitoneal complications

Intraperitoneal CO_2 insufflation and changes in patient's position during the laparoscopic intervention have several hemodynamic, pulmonary and endocrine impacts clinically manifested by hemodynamic impairments and cardiac symptoms.

Severe hemodynamic complications of laparoscopic intervention include blood pressure alterations (hypotension and hypertension), dysrhythmias and heart failure. The most of asystolic cases occur during the conduction of pneumoperitoneum. Hemodynamic changes during laparoscopy usually fluctuate as to their intensity. Due to the fact that compensatory mechanisms stabilizing the hemodynamics are limited, each subsequent peroperative intervention (response to anaesthetics or bleeding) in patients compromised by cardiac diseases can lead to cardiac failure.

Cardiac collapse during laparoscopy can be caused by the following states:

– Severe vagovasal reaction
– Cardiac dysrhythmia
– Excessive intra-abdominal pressure
– Acute blood loss
– Myocardial dysfunction
– Tensional pneumothorax
– Severe respiratory acidosis
– Pulmonary embolism
– Cardiac tamponade
– Adverse effects of anaesthetics

Dysrhythmias occur in 14 % of laparoscopic interventions. Most important are bradyarrhythmias including significant bradycardia, atrioventricular dissociation, nodal rhythms and asystole. These manifestations of vagal stimulation can be caused by an insertion of Veress's needle or trocar, pneumoperitoneum-induced distension of peritoneal cavity, irritation of vegetative innervation of visceral organs during electric cauterisation or CO_2 embolism. In addition to the latter, also tachyrhythmias can occur due to increased concentrations of CO_2 and catecholamines.

Objectives

The objective of this prospective study was to achieve the following:

1) To assess the predictive value of concomitant diseases of CVS, pulmonary diseases with ventilation disorders of obstructive or restrictive types and renal and metabolic diseases in the potential origin of hemodynamic cardiopulmonary complications due to insufflated capnoperitoneum in laparoscopic surgery.

2) Based on standard clinical parameters of monitoring of hemodynamics and respiration to observe the course of laparoscopic operation with the use of CO_2 pneumoperitoneum in this group of patients. To compare them with biologic markers activated by, and responding to hemodynamic, cardiac and respiratory dysfunctions. By means of the latter to pronounce the assumption as to whether laparoscopic operation represents an excessive risk for patients with above diseases and to find out whether for patients being in the presented categories of risks the use of capnoperitoneum represents a severe risk of preoperative or early postoperative complications.

3) By means of statistical processing to find out how significantly the increase in IAP influences the measured parameters in this group of patients.

Patients and methods

The clinical study included 11 patients at moderate or severe anaesthetic or cardiac risks of ASA III-IV and NYHA II-III. The selection of patients and the judgement of the severity of their

Tab. 2. Maximal and minimal values of investigated biologic markers.

Parameter	Value		
	before	15th min	30th min
ANP (pg/ml)	24.78–91.51	23.82–312.6	18.71–294.2
PRA (ng/ml)	0.11–6.88	0.19–12.96	0.09–16.52
DA (ng/ml)	4.55–76.40	9.89–95.61	7.66–54.69
Adrenaline (ng/ml)	0.37–2.31	0.74–13.50	0.80–11.14
Noradrenaline (ng/ml)	2.51–28.91	3.22–41.70	4.74–23.46

Standard values: ANP <43.00 pg/ml,
PRA 0.50–1.90 ng/ml, DA <100 ng/ml, Adrenaline <100 ng/ml, Noradrenaline <600 ng/ml
ANP – atrial natriuretic peptide, PRA – plasmatic renin activity, DA – dopamine

CVS and pulmonary diseases as well as that of other concomitant diseases were done on an interdisciplinary basis of clinical objectification (case-history, physical examination, biochemical, functional and imaging examinations), i.e. it was performed by surgical internists, cardiologist, anaesthesiologist and surgeon. Patients included into the study suffered from ischemic heart disease, arterial hypertension of stage II or III, obstructive or restrictive ventilation disorder, obesity, chronic renal insufficiency or diabetes mellitus. The concomitant diseases were in various combinations however the patients were categorized into above risk groups on the basis of at least three factors. At the time of the assessment of surgery indication, the concomitant diseases were compensated, under control with an appropriate functional reserve.

Indications of laparoscopic mode of surgery were based on the presence of symptomatic diseases of gall bladder, gastroesophageal reflux and renal adenoma. The patients have been duly informed on preoperative observations and potential perioperative complications in the course of laparoscopic intervention, and included into the study with their consent.

The essence of the study was to investigate the standard clinical markers of monitoring the cardiovascular and respiratory surgeries. In addition to the evaluation of clinical markers, the objectification of the stage of hemodynamic and cardiovascular stress was achieved by the assessment of some neurohumoral substances intermediating the adaptational reactions of circulation in frame of neuroendocrine activation serving as preservers of MO and BP homeostasis. Observed were the changes in levels of specific peptides, namely those of ANP, PRA, catecholamines and dopamine resulting from hemodynamic consequences of increased IAP brought about by insufflated capnoperitoneum in the 15th and 30th minute of its duration in comparison with their preoperative values. Analyses were done by means of ligand methods, namely ANP (Nichols Institute, UK), PRA (Immunotech France) and catecholamines (Catechola, Immunotech Praha, Czech Republic).

The measured values of investigated parameters were evaluated in three ways.

1) We recorded their absolute values and compared them with their normal physiologic or standard values, or those gained within individual phases of measurement.
2) The measured parameters were statistically processed by means of Student t-test with the intention to find out and confirm the significance of the impact of pneumoperitoneal insufflation on observed parameters.
3) By use of regression analysis we have expressed the change in reaction of individual markers in dependence on changes in conditions brought about by capnoperitoneum. This method has thereby enabled us to analyse how the values of independent variable factor of insufflation influence the dependent parameters (ANP, KA, PRA, CVP.). At the same time, according to the development of regression line (its steepness or decline), this analysis has enabled us to predict the trends of dependence in a similar not tested group (14).

Results

The highest initial preoperative ANP value of 91.51 pg/ml was measured in a patient after 2 myocardial infarctions with EF 40 % (ASA IV, NYHA III) (Tab. 2). Six patients had their initial values in the standard range. The values of other five were only mildly increased above the standard. In five patients, ANP values measured in the 15th minute after the insufflation of capnoperitoneum were mildly below their initial values, and in other five patients they increased slightly. The maximum increase of 4-fold was recorded in a patient evaluated as ASA III–IV and NYHA II–III on the basis of ischemic heart disease, chronic glomerulonephritis, and secondary hypertension with BMI of 35. However, also the ANP value was the highest but one when compared with input values. After further 30 minutes ANP values increased, however only mildly in three of the patients. The ANP regression line prior to operation and 15 minutes after insufflation had only a mildly increasing trend and its course was almost identical with the line of values measured in 15th and 30th minutes of capnoperitoneum duration (Fig. 1). During the testing of this parameter by means of pair Student t-test we found out that the changes between mean ANP values prior to, after and during insufflation were not statistically significant ($p>0.01$).

From the aspect of the predicted reaction under the currently known effects of pneumoperitoneum on splanchnic circulation, more balanced values were measured in PRA, where only in one

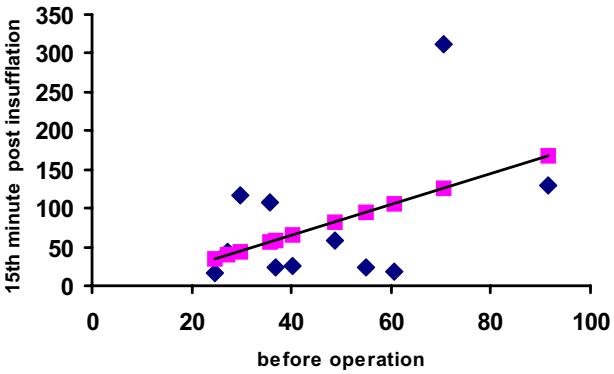

Fig. 1. Regression line of ANP prior to operation in the 15th minute after insufflation

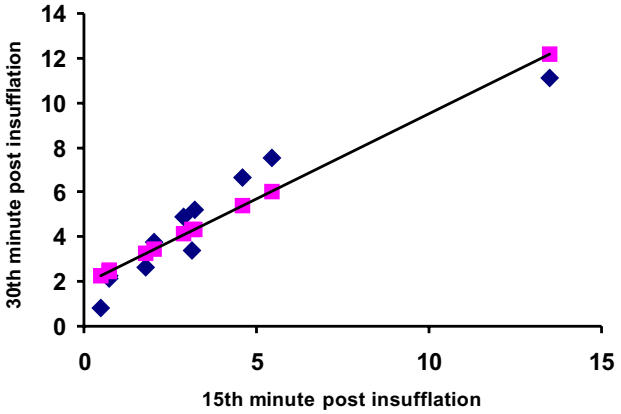

Fig. 3. Regression line of adrenaline values in the 15th and 30th minutes after insufflation

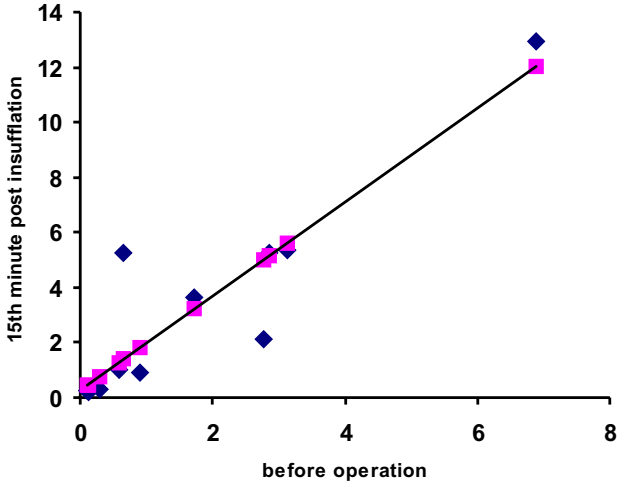

Fig. 2. Regression line of PRA values prior to operation in the 15th minute after insufflation

patient the post-insufflation value was below the standard. The absolute PRA value measured in the 15th minute after insufflation increased in 7 patients, however in the 30th minute the latter number of patients increased up to 9. The highest, i.e. 9-fold increase when compared with the initial pre-insufflation value appeared again in the patient with hypertension secondary to renal disease and obesity (BMI 35). The regression line had an increasing steep trend in both comparisons, i.e. prior to and after the insufflation, and during the course of capnoperitoneum (Fig. 2). Such a course of line signals a relatively high dependence of PRA on increased IAP. Despite this, the analysis by means of Student t-test detected a significant change neither in PRA and the latter detection was observed neither after, nor during the insufflation ($p>0.01$).

The analysis of dopamine showed that in 7 cases the post-insufflation value exceeded the preoperative value and only in three patients it did not yield an increase in the 30th minute of pneumoperitoneum. Being NA precursor, dopamine reacted in the 15th minute of insufflation similarly to NA. The values of dopamine were in both periods of observation significantly dispersed. Neither in one case they exceeded the standard values. In three cases however their increase in the first measured phase was significant. The reaction of dopamine was missing in a patient who had undergone a surgery of adrenal glands. In the picture of regression analysis the lines in respect of this parameter had prior to and after the insufflation mildly increasing trends when compared with a slowly decreasing trend of the dopamine level measured during capnoperitoneum. The Student t-test has proved a non-significant difference in the measured values of dopamine in regard to the effect of capnoperitoneum as well as to the time of its course ($p>0.01$).

In two further catecholamines – adrenaline and noradrenaline (NA), all measured values were in the standard range. In case of adrenaline only in one patient a mild decrease occurred after insufflation. In other 10 cases, the values measured after insufflation were higher than those gained prior to insufflation. The values of adrenaline measured in the 30th minute of the duration of capnoperitoneum were higher than those obtained in the 15th minute after insufflation. In case of noradrenaline, when compared with its pre-insufflation values, the decrease occurred also only in one patient. In another patients an almost 10-fold higher increase took place. It was most significant in the patient with EF 45 %, pulmonary hypertension, hypokinesis IVS. During capnoperitoneum, the NA level became stable and only in three patients it increased slightly. The regression line of adrenaline in the course of pneumoperitoneum was of a significantly steeper character (Fig. 3) than the line characterizing the adrenaline trend prior to and after insufflation. Its course was almost parallel to the x-axis. This could indicate that there is a dependence of the increasing production of adrenaline on the duration of CO_2 peritoneum. The NA regression line comparing NA trends prior to and after the insufflation had a minimum steepness. Twofold steeper was however the line evaluating this parameter during capnoperitoneum. The Student t-test however proved the statistical dependence of neither adrenaline, nor NA on increased IAP in both measured intervals of capnoperitoneum ($p>0.01$).

The values of *systolic blood pressure* at the beginning of anaesthesia prior to insufflation dropped in no patient below 125 Torr or exceeded 150 Torr of systole. After the insufflation, a decrease in systolic pressure occurred in 9 patients by 30 Torr of systole in average. Only in two patients the systolic BP increased slightly. In one case by 10 Torr and in the other by 40 Torr, which however in 10 minutes returned to its normal preoperative value. The line of linear regression of systolic blood pressure analysing its development prior to and after insufflation was only slightly increasing as opposed to the steep increase of the line evaluating the systolic BP during capnoperitoneum, the fact of which gives the assumption of dependence of systolic BP on insufflation IAP. The pair t-test values however did not prove this assumption statistically.

The values of diastolic blood pressure yielded a greater dispersion than those of systolic blood pressure. In four patients the diastolic pressure exceeded the standard value and during the operation only sporadically decreased below 100 Torr. The highest value of diastolic pressure also in these four patients was that occurring prior to insufflation. The regression line of diastolic pressure has in both measured intervals nearly the same mildly increasing trends. Also in this case no significant relation between the measured values of pressure and the origin or duration of capnoperitoneum ($p>0.01$) was found by means of Student t-test.

The CVP values in result of insufflation increased in all patients, in average by 3 cmH_2O. 3 cmH_2O were as a rule added to the measured value taken after intubating the patients and connecting them to artificial pulmonary ventilation. The CVP values measured during insufflation were stable and no significant fluctuations were recorded. The regression line evaluating the CVP prior and after the insufflation increases mildly in a 30-degree angle, whereas during capnoperitoneum it runs more flat and parallel to the x-axis. When analysing the pair Student t-test only this parameter out of all investigated parameters has a statistically significant relation to capnoperitoneum ($p>0.01$).

The last clinical marker to be evaluated was the heart rate. In three patients it decreased after 10 minutes of insufflation by more than 30 min^{-1}, the state of which necessitated a medicamentous intervention (Atropine). The frequency higher than 100 min^{-1} was not found during the measurement. The regression line of measured values prior to and after insufflation has a more flat decrease of 20 degrees, the fact of which indicates a small dependence on the developed capnoperitoneum. The stability and steadiness of this parameter is documented by a mildly decreasing regression line in the course of insufflated capnoperitoneum. The HR value was not influenced statistically by the development and duration of pneumoperitoneum ($p<0.01$).

Discussion

In some situations of conventional surgery it is complicated to use the prognostic systems to assess the surgical risk and predilection factors and thus to stratify patients as to the adequacy of risk of laparoscopic operation performed with the use of capnoperitoneum. When judging the surgical risk in general, it is possible to base the considerations on accepted and respected procedures of its assessment in open non-heart surgeries. In laparoscopic operations, the increased IAP brought about by CO_2 insufflation remains to be a problem together with all its known consequences, especially those affecting the CVS and hemodynamics. Pathologic causality and interactions of mechanic, chemical and neurohumoral reactions to insufflation created a new, scarcely known, sometimes enigmatic factor that influences even simple surgical interventions. The estimation of risk then becomes uncertain, especially should elective surgery be indicated in patients suffering from limited CV functions or severe extracardiac, especially pulmonary diseases.

During surgery, it is not simple to observe subclinical signs of cardiac failure or deteriorating myocardial functions signalling the disorders in cardiac hemodynamic functions integrated by neurohumoral system. The currently published, especially experimental studies imply that the increased IAP causes an increase in SVR, reduces CO (cardiac output), and increases the afterload, the facts of which can lead to overloading the cardiac muscle and activating the compensatory mechanisms, in the first phase especially the neuroendocrine mechanisms. In our study we have observed the level of ANP together with other biochemical markers being activated by decreased MO, visceral or systemic hypoperfusion or hypoxemia. ANP is a recently discovered hormone, primarily excreted by atrial myocytes in response to both acute and chronic volume overload. Atrial distension and an increase in the level of plasmatic ANP at the same time signals central hypervolemia. An increase in plasmatic ANP can be expected in clinical states associated with an increase in atrial pressure due to tachyarrhythmia, congestive cardiac failure and various disorders associated with the expansion of extracellular fluid volume (acute and chronic renal failures). Plasmatic level of ANP closely corresponds with indicators of congestive cardiac failure (CCF) severity, namely in continual proportion with left atrial pressure and capillary pulmonary pressure in block and in reciprocal proportion with cardiac index, ejection volume, blood pressure and NYHA classification of function (16, 2).

In two patients during the period of increased ANP after insufflation we have not found any significant changes in other clinical hemodynamic markers. Both patients had stable values of blood pressure, regular and normal heart rates and stable CVP. It has been proved that the development of pneumoperitoneum is associated with an increase in cardiac filling pressures (1, 7). Increased filling in central circulation is one of the mechanisms of increased atrial tension and an impulse for drifting ANP into the circulation. Capnoperitoneum brings about great changes in atrial pressures being synchronic with respiration, the fact of which can represent a further stimulus enhancing the production of ANP. High pre-operative levels of ANP in some patients of our group are the consequence of cardiac dysfunction proved echocardiographically, and imply from pathophysiological and pathomorphological changes in arterial hypertension and chronic ischemic heart disease. Individuals with healthy hearts and those with cardiac diseases without congestive failure have ANP plas-

matic levels ranging from 10 to 50 pmol/l, whereas its levels in patients with congestive cardiac failure is about 100 pmol/l. The values can however vary within a significant range. Postinsufflation ANP values that should serve as markers of increased atrial tension in coincidence with increased central filling, increased values of which could be responsible for the decrease in contractility, decreased preload and thus also decreased output after the development of pneumoperitoneum, were not recorded to increase significantly. In a patient with its high pre-operative value, the increased intraabdominal pressure caused only a small increase in ANP during the surgery. In this patient however, in the 30th minute, a 10-fold adrenaline increase occurred. Out of all known antagonistic relations of ANP to catecholamines (16) it can be deduced that the increased ANP activity and its impacts on the central as well as on peripheral hemodynamics induced an adrenergic reaction in the further course of operation in order to maintain the hemodynamic stability. Also in other cases, ANP decreased or changed to a minimum extent when compared to pre-operative values or values measured in the 15th minute. The explanation can be dual: 1) The atrial tension or increased intracardiac volume is not sufficiently significant to cause an increase in ANP excretion, 2) The current activation of adrenomedullary sympathetic response by the increased excretion of catecholamines compensated or inhibited the mechanisms leading to the ANP increase. A similar reaction of ANP can be expected also in other patients at the same operation risks. The statistical significance of ANP corresponded with the clinical course and investigated hemodynamic parameters during the surgery. After processing our results, most precious is the finding that ANP values measured in our patients obviously eliminate the graduation of cardiac dysfunction and cardiac failure.

One of the most important responses to stress is the increase in plasmatic concentration of catecholamines. The sympathetic activation is part of the alarm reaction in response to life endangerment. This reaction, however, becomes pathologic and long-term in heart failure. It is brought about either by decreased MO liable to a decrease in blood pressure (low output), or by increased MO due to excessive vasodilatation (high output) (18). The sympathetic adrenergic reaction is reflexive and immediate, relieved by the excretion of ANP. The evaluation of clinical significance of catecholamines is complex. The up-to-now performed observation of catecholamines in response to capnoperitoneum only states their increase without evaluating the adverse impacts on circulation. Neither in this range, the sole fact that the levels of adrenaline, noradrenaline and dopamine were within the standard range can be the equivalent of only physiologic, effective impact on the receptors in effector organs, especially on those in the heart and vascular system. Their real protective impact on the improvement of cardiac output, the maintenance of homeostatic blood pressure, the effect on peripheral vascular resistance and the maintenance of stability and normal heart action during laparoscopic surgery are highly individual. To compare the neuroendocrine response, the authors observed (21) the levels of plasmatic adrenaline and NA in chronically stressed patients at intensive care units, in patients after resuscitation due to cardiac stoppage and the levels in the control group of healthy stress-free subjects. In the first group the maximum of adrenaline level increase was 4-fold and that of noradrenaline 2-fold. In patients after resuscitation due to cardiac stoppage however they increased 300-fold and in case of noradrenaline 30-fold when compared with the control group of healthy stress-free subjects. The maximum measured value in this group was 35.9 ng/ml in adrenaline and 7.37 ng/ml in noradrenaline (i.e. in standard range of values). In our group the maximum level of adrenaline was 13.5 ng/ml and that of noradrenaline was 41.70 ng/ml.

The other possibility to compare the ineffective, or adverse effects of catecholamines is to evaluate other clinical markers by means of which it is possible to judge the stimulation effect of catecholamines. During capnoperitoneum, none of our 11 patients developed arrhythmia, uncontrolled hypertension reaction, excessive tachycardia or signs of heart failure. It can be therefore stated that despite the increasing plasmatic level of catecholamines, the adrenergic response to IAP increase had a serious effect neither in patients with moderate or severe peri-operational risks.

Our results, namely variable reactions and plasmatic levels of individual catecholamines hint some pathophysiological changes and the specificity of neuroendocrine response determined by increased intraabdominal pressure after the development of capnoperitoneum. The increased level of adrenaline after insufflation, despite its mild progression during the latter period, suggests a protective adrenomedullary reaction caused by capnoperitoneum, or increased intraabdomial pressure, where the visceral hypoperfusion is assumingly the factor stimulating the increase in the production of adrenaline. The current increase in adrenaline in the 15th minute after insufflation of the capnoperitoneum is very probably a reaction to the connection of the sympathetic nervous system in the distribution of blood volume from the abdominal to the thoracic compartment in order to maintain the homeostatic blood pressure. The increase in the venous return by redistribution of blood from the abdominal to the thoracic compartment is suggested also by a significant increase in CVP.

The decrease in renal blood flow brought about by the compression of visceral circulation due to increased intraabdominal pressure and the shift of blood from the abdominal compartment as well as neurohumoral factors (increased noradrenaline levels) affect the renal perfusion. These factors only stimulate the increase in the secretion of renin and its activity within the plasma.

The renin-angiotensin system is one of the main neurohumoral regulators of physiologic homeostasis. From the physiologic aspect, hypertension and heart failure belong to most significant diseases, among which the RAAS activation plays the key role (12). In our group, 6 patients reacted to an increase in the intraabdominal pressure by a more than 2-fold increase in plasmatic renin activity level. In two patients, the increase was especially high (3- or 9-fold). Both patients suffered from renal diseases. In them, also the NA level increased (9- or 4-fold). These findings correlated with pathophysiologic mechanisms controlling the increased secretion of renin, however not leading

to the deterioration of renal functions in the postoperative period. In addition to the latter, hypertensive reaction did not occur either in the perioperative period. Our PRA measurements were in agreement with the findings of other authors (18). During the peritoneal insufflation, the blood pressure in all investigated patients was controlled and no case required medicamentous correction. Immediately after the intubation systolic hypertension was measured in both patients, however within a period of several minutes it became stable again. In our group though, we did find a positive correlation between the increased values of renin plasmatic activity and increased arterial pressure during CO_2 pneumoperitoneum.

The judgement of hemodynamic response to operative stress is routinely done by use of clinical hemodynamic markers – blood pressure, heart frequency and CVP, the changes of which are especially important in observing central hemodynamics in coincidence with laparoscopic operations associated with pneumoperitoneum. The heart rate is an obligational hemodynamic parameter in coincidence with stress. The response is considered to be pathologic when there is non-adequate increase in heart rate or bradycardia. Should we consider the increased heart rate to be an adaptational reaction of circulation to stress, then at the same time the heart rate is the simplest indirect indicator of oxygen consumption. In patients with limited ventricular function the increase in heart frequency becomes a more obvious compensatory mechanism than the increase in contractility by means of triggering the Starling mechanism. We are aware of the fact that peroperative evaluation of heart rate can be influenced by chronic medicamentous therapy (e.g by betablockers), premedication (atropine) or by chronic impact of some anaesthetics. Despite this, in our group there was no excessive tachycardia that would require medicamentous intervention. The sympathetic adrenergic stimulation expressed by the secretion of catecholamines was in correlation with the chronotropic response within the course of surgery.

The values of blood pressure are determined by the circulation volume dependent on the minute heart volume and SVR. In the assumed isovolemia being the basic requirement of safe elective operation, significant is the decrease or increase in blood pressure determined by SCR change or TO reduction. In our group of patients being limited especially by IHD and blood hypertension and thus classified as being at risk of ASA III and IV and NYHA III we have recorded the most significant changes in blood pressure prior to and after intubation. The insufflation of capnoperitoneum and the increase in intraabdominal pressure did not affect either the values of systolic nor diastolic pressures, which were stable during the course of capnoperitoneum, with minimum fluctuation, well controlled, and medicamentous intervention or volume correction was required in no patients. Blood pressure being a simply measurable parameter is usually an insufficiently recognized marker of hemodynamics despite the fact that due to its sensitivity in expressing the changes in vascular and cardiac hemodynamics it can be considered as a sensitive predictor of circulatory disorders. The evaluation of blood pressure changes in absolute values is of no objective value unless it exceeds the extreme threshold of hypotension or hypertension. Therefore the ability to increase the pressure during peroperative stress by 10 or 30 Torr is a better indicator of hemodynamic flexibility of the vascular system and regulatory mechanisms of myocardium. The capability of this reaction was recognised in all our investigated patients, the fact of which was evaluated as a favourable prognostic sign.

The opinions clash mostly in case of the venous return. Early experimental works proved a decrease in venous return caused by an increase in intraabdominal pressure as a result of increased venous resistance brought about by compressive effect of pneumoperitoneum in intraabdominal compartment. Later works proved an adverse effect of capnoperitoneum on venous return. Its increase results from the shift of blood from abdominal compartment to central circulation. The fears of decreased preload, decreased RV output, which in coincidence with stress affect the systemic circulation with all consequences for both ventricles, have been proved to be unjustified. The factors that can increase the ventricular preload include the venous blood pressure and the stage of venous return. Due to the fact that LV is preload-dependent, the venous blood pressure at maintained transpulmonary circulation is the basic precondition of optimal LV function. By using CVP measurement in individual phases of operation we have proved the fact that by means of insufflating the peritoneum and increasing the intra-abdominal pressure, the venous return and venous pressure increase.

Under stable hemodynamic stable conditions the venous return must be practically equal to cardiac output. CVP is always naturally driven onwards to the value, which creates balance between•cardiac output and venous return. CVP of 2 cmHg coincides with cardiac output of about 5 l/min. Moreover, the alteration in this parameter was the only statistically significant change.

Conclusion

On the basis of approximation of experimental works on adverse effects and complications of capnoperitoneum and on the ground of our own clinical experience supported by the presented clinical study we can carefully formulate the following conclusions:

– Biologic ANP markers, catecholamines and PRA were increasing non-significantly and did not signal the deepening of cardiac dysfunction, latent cardiac failure or a hemodynamic disorder. Their values correlated with clinical hemodynamic markers of BP and heart rate.

– We have proved that the increase in IAP causes a significant increase in CVP, i.e. in one of critical factors influencing the RV pre-load. At intact transpulmonary circulation it optimises also the LV function. At the same time it can be assumed that SVR in course of capnoperitoneum does not alter the systemic hemodynamics. The fear of increased CVP and thus of venous return seems to be unjustified.

– Clinical hemodynamic markers, namely BP and heart rate are sufficiently sensitive parameters for monitoring the circula-

tion. Their values correlated with the levels of catecholamines, PRA and ANP.

– None of our patients developed cardiac, respiratory or hemodynamic complications requiring inotropic, excessive voluminous, antiarrhythmic or anti hypertensive medicamentous therapy. At the same time there was no need to desufflate the capnoperitoneum or to decrease the intraabdominal pressure.

– The peroperative clinical and biologic markers of hemodynamic and neuroendocrine responses to operative stress and the development of CO_2 pneumoperitoneum in our investigation has proved that patients classified as being at risk of ASA III–IV and NYHA III do not necessarily have to have a complicated course of laparoscopic operation. It can be assumed that the increased values of biologic markers regulated the neurohumoral responses in the physiologic range and did not predict any severe dysfunction of CVS within its course.

– According to our findings, the case history of NYHA III stage of IHD, EF of 40 %, stage III of arterial hypertension, renal diseases, obesity with BMI of over 30, as well as of severe pulmonary diseases also in combination shifting the patients into classes of severe risk of cardiac preoperative complications, do not have to be negative predictors of laparoscopic technique of operation.

– Regarding the discovered correlations of preoperative clinical markers with biochemical parameters of neuroendocrine regulation of CVS, renal functions and respiration, the standard clinical monitoring can be considered as sufficient for discerning the potential complications caused by capnoperitoneum.

The identification of risk factors, their precise objectification and optimal immediate pre-operative preparation with correction of electrolyte abnormalities, protection of adequate intravascular volume, correction of anemia and hypoproteinemia, compensation of diabetes mellitus, stabilisation of hypertension and pre-operative breathing exercise minimize the occurrence or perioperative complications.

In patients at moderate or severe risk and treated by laparoscopic surgery, it is necessary to target the perioperative monitoring. Anaesthesia has to be conducted by an experienced anaesthesiologist who is aware of, able to discern and correct the potential cardiac, respiratory and hemodynamic complications caused by capnoperitoneum.

Based on current published data as well as on the ground of our experience we believe that the adverse effects of capnoperitoneum on hemodynamics and cardiac functions are often overestimated. This fact can be proved by the small number of conversions and nil mortality due to the above cause at our clinic.

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