Worsening of Heart Failure after Abdominal Surgery – Can we predict it?

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ABSTRACT

Background: The cardiopulmonary test has demonstrated its role in predicting long term prognostic of patients with heart failure, but only few data are available regarding its utility on short term period.

Methods: During 2011-2013, the study enrolled 55 patients over 18 years, with different cardiovascular, metabolic and/or pulmonary pathologies, and 10 control patients matched for age, sex and surgical intervention type, without an associated pathological history who underwent elective abdominal surgery with general anesthesia.

Results: The most important predictors of the heart failure worsening after abdominal surgery were peak VO2 as percent of predicted VO2 lower than 59.42±12.52, ventilator equivalent for CO2 at anaerobic threshold over 39.53±5.27 and VD/VT ratio at anaerobic threshold over 0.33±0.06. Lean VO2 lower than 9.58±2.47 also correlated with the above mentioned complication. The ventilator equivalent for CO2, above 39.53±5.27 at anaerobic threshold, respectively 40.67±6.73 at peak exercise, correlates with short term worsening of heart failure after general anesthesia for abdominal surgery.

Conclusion: The CPX test has a certain value in predicting short term worsening of heart failure after general anesthesia for elective abdominal surgery in patients known with cardiovascular, pulmonary and/or metabolic disorders.

INTRODUCTION

Heart failure is one of the most important healthcare problems, associated with high morbidity and mortality rates. Cardiopulmonary exercise testing (CPX) provides significant value regarding heart failure diagnosis, prognosis and long term risk assessment. The most widely used variable in research and also in clinical settings is peak oxygen consumption (peak VO2) (1,2). Lately, other variables, such as minute ventilation (VE) and carbon dioxide production (VCO2) slope and the partial pressure of end-tidal CO2 (pET-CO2), have been used to provide prognostic information (3-5). Although all these parameters have shown their efficiency in predicting long term complications of patients with different NYHA classes of heart failure, only very little data is available, at this moment, regarding their prognostic utility on short term period, such as postoperative period (6).
OBJECTIVES

The aim of this study was to establish if CPX parameters could predict worsening of heart failure on short term period in patients undergoing elective abdominal surgery with general anesthesia.

MATERIALS AND METHODS

This study was a prospective one: during the period 2011-2013 were enrolled 55 patients over 18 years, with different cardiovascular, metabolic and/or pulmonary pathologies, and 10 control patients matched for age, sex and surgical intervention type, without an associated pathological history, who underwent elective abdominal surgery with general anesthesia; patients with contraindications for CPX test and those with inaccurate echocardiographic images were excluded.

The general characteristics of the two groups of patients are showed in the table below (Table 1):

- 24 patients had a history of heart failure (18 patients NYHA II, 5 patients NYHA III, 1 patient NYHA IV). Because patients undergoing elective surgery interventions were enrolled, if the cardiac examination performed before surgery had revealed signs of NYHA class III-IV, the surgery would have been postponed until the patients were compensated. Therefore, all the patients who performed CPX test were at most in NYHA class II. Only 3 patients presented LBBB. Regarding the cardiovascular treatment, we found that although the patients had a significant cardiovascular history, the percentage of treated patients according to the current guidelines was low (beta blockers 36.4%, ACE-I 38.2%, ARB 20%, diuretics 43.6%, digoxin 3.6%, Aspirin 47.3%, statins 30.9%).

- The most frequent surgery interventions performed were the ball bladder and biliary tract surgeries on 22 patients (40%), followed by colon surgeries on 18 patients (32.7%) and stomach/duodenum surgeries on 7 patients (12.7%); the others interventions were: rectum (5.45%), pancreas (3.64%), hernia (3.69%) and spleen (1.82%).

Before the surgery, the patients were thoroughly evaluated: past and present diseases were noted, general and cardiovascular clinical examinations were made and the following investigations were performed: 12 leads rest electrocardiogram, chest X-ray, spirometry, echocardiography and, of course, CPX test.

After the surgery all the patients were followed-up clinical and biological until discharge, paying attention to possible cardiovascular complications, especially to worsening of the heart failure. This was diagnosed by the appearance of the proto-diastolic gallop, pulmonary crackles, raised jugular venous pressure, hepatomegaly or pedal edema. If none of these signs were present, and after the patient was considered fit for effort from the surgical point of view and after the hemoglobin was equilibrated, we evaluated the NYHA class by using the correlation between it and the Goldman effort scale (7). The capacity of effort, measured in METs, was determined using a questioner which was validated by the ACC/AHA guidelines update for perioperative cardiovascular evaluation for noncardiac surgery (8-10). We considered: NYHA class I: >7 METs; NYHA class II: 5-7 METs; NYHA class III: 2-5 METs; NYHA class IV: <2 METs. Indicators of functional status include the following:

- Can take care of self, such as eat, dress or use the toilet (1 MET)
- Can walk up a flight of steps or a hill (4 METs)
- Can do heavy work around the house such as scrubbing floors or lifting or moving heavy furniture (between 4 and 10 METs)
- Can participate in strenuous sports such as swimming, singles tennis, football, basketball, and skiing (>10 METs)

The echocardiographic studies were performed on VIVID 9 (GE Medical). The images were obtained using a transducer of 1.5-5 MHz with high temporal and spatial resolution. The images were sent to a workstation with software (EchoPAC BT 09, GE Medical) for analysis. The CPX test was performed on treadmill using a GE Medical device with a CardioSoft

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>60.18 ±11.8</td>
</tr>
<tr>
<td>Sex (masculine)</td>
<td>28 (50.9%)</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>27.78 ± 4.45</td>
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<tr>
<td>Obesity</td>
<td>13 (23.6%)</td>
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<tr>
<td>Rest systolic BP (mmHg)</td>
<td>136.15 ±18.41</td>
</tr>
<tr>
<td>Peak systolic BP (mmHg)</td>
<td>186.40 ± 37.30</td>
</tr>
<tr>
<td>Rest diastolic BP (mmHg)</td>
<td>79.8±10.31</td>
</tr>
<tr>
<td>Peak diastolic BP (mmHg)</td>
<td>90.4±16.82</td>
</tr>
<tr>
<td>Rest heart rate (bpm)</td>
<td>82.16 ± 12.65</td>
</tr>
</tbody>
</table>

TABLE 1. Demographic characteristics of the studied groups.

BMI: Body Mass Index, BP: blood pressure.
operating module for ECG test and a MetaSoft module for spirometry. The patients performed the test after at least 3 hours after having their last meal and they were asked not to smoke or to drink alcohol or coffee on the test day (11).

Regarding the treatment, the beta blockers were interrupted with one day before the test. The statistical analysis was performed with SPSS, Version 16.0, SPSS Inc. Chicago, Illinois and Microsoft Excel.

RESULTS

No one of the control patients experienced cardiovascular or pulmonary complications following surgical procedure.

Twelve patients from the study group experienced worsening of heart failure NYHA class after undergoing surgery. We noticed that even the patients with mild to moderate left ventricle systolic dysfunction (LVEF 42±6.5%) were susceptible to increase NYHA class after the surgery (Table 2). Using the t-test, we revealed a statistically significant reverse correlation between the value of systolic pulmonary artery pressure and this complication ($t = -4.50$, $p=0.0001$). The higher the systolic pulmonary artery pressure was, the more the patients were predisposed to worsening the heart failure after surgery. Regarding the E/E mitral TDI ratio, both subgroups of patients had values between 8 and 15, being placed in the “grey zone”. Using the t-test, we revealed a statistic significant reverse correlation between the E/E mitral TDI ratio and the worsening of heart failure after surgery ($t=-3.68$, $p=0.001$). Thus, the closer the value of this ratio was to the beginning of the “grey zone”, the more the patients succeeded to maintain their preoperative NYHA class (29±2.13) (11). There weren’t any significant correlations between the longitudinal left ventricle dysfunction and the worsening of heart failure after the surgery. A last parameter which showed significant statistic differences between patients that presented worsening of heart failure after surgery and those that didn’t have this complication was filling time. A filling time of 0.54±0.05 % of cardiac cycle duration was correlated with no worsening of the heart failure after abdominal surgery (Table 2).

From the CPX parameters (Table 3), the most important predictors of the heart failure worsening after abdominal surgery were peak VO2 as percent of predicted VO2, lower than 59.42±12.52, ventilator equivalent for CO2 at anaerobic threshold over 39.53±5.27 and VD/VT ratio at anaerobic threshold over 0.33±0.06. Another reliable parameter, named lean VO2, obtained by dividing the value of VO2 at AT to patient’s weight, correlated with the above mentioned complication. The ventilator equivalent for CO2, above 39.53±5.27 at anaerobic threshold, respectively 40.67±6.73 at peak exercise, correlates with short term worsening of heart failure after general anesthesia for abdominal surgery.

We also studied some others CPX parameters, but these ones didn’t correlate (p-value >0.05) with worsening of the heart failure: VO2 at AT (l/min), VO2 at AT % of peak, O2 pulse at AT % of peak, O2 pulse at peak (ml/beat), O2 pulse at peak as % of predicted, VCO2.
DISCUSSIONS

There is a constant concern worldwide to improve the preoperative evaluation of the elective patients, in order to reduce as more as possible the risk (12,13). The echocardiography is a static investigation which doesn’t correlate always with the patient’s functional capacity, therefore there are patients with left ventricle systolic dysfunction and good effort capacity and there are patients with preserved left ventricle ejection fraction, but low effort capacity. The cardiopulmonary test is a dynamic investigation, which integrates the cardiac, vascular, metabolic, muscular and pulmonary patient’s status. We consider that CPX testing closely mimics the intra- and postoperative situation, as it requires an increased cardiac output in order to satisfy the increased oxygen demand.

The most important predictors of the heart failure worsening after abdominal surgery from the CPX parameters were: peak VO$_2$, ventilator equivalent for CO$_2$ at anaerobic threshold, VD/VT ratio at anaerobic threshold. Although the VO$_2$ at AT didn’t correlate with worsening of heart failure, by dividing its value to patient’s weight, we obtained a more reliable parameter named lean VO$_2$ which correlated with worsening of heart failure. This could be explained by the fact that usually, a higher weight is based mainly on adipose tissue rather than muscular mass (which participate at effort and consequently consuming oxygen), so reporting a pulmonary volume per kg eliminates the weight’s influence over that parameter. As demonstrated in previous studies, the ventilator equivalent for CO$_2$ above 34 at anaerobic threshold was an independent risk factor for poor long term prognosis at the patients with heart failure (14).

We found that this parameter also correlates with short term worsening of heart failure after general anesthesia for abdominal surgery, but at higher values than the one specified for long term prognosis.

LIMITS

Because the study involved the cardiopulmonary test, the patients with physical disabilities or urgent indications for abdominal surgery were excluded, therefore the enrolment of patients couldn’t be successive and the results of this study cannot be applied to all categories of patients undergoing abdominal surgery.

This study included a reduced number of patients and therefore also resulted a reduced number of perioperative complications. This could be a reason why some of the investigated parameters didn’t reached the statistical significance.

CONCLUSIONS

The CPX test could be used in predicting short term worsening of heart failure after general anesthesia for elective abdominal surgery in patients known with cardiovascular, pulmonary and/or metabolic disorders.

Based on the fact that most of the CPX parameters that correlated themselves with worsening of heart failure after abdominal surgery presented predictor values from the moment of the anaerobic threshold, we encourage the use of anaerobic threshold values over the peak values in assessing the risk of postoperative complications, because the AT is independent from the motivation of the patient, it is readily obtained even in elderly patients, it occurs well before the maximum capacity and we can relieve the preoperative patients of high physical stress.

Conflict of interest: none declared.
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REFERENCES

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