Duke Activity Status Index in Coronary Patients Undergoing Abdominal Nonvascular Surgery

V Karapandzic, M Petrovic, Z Krivokapic, V Masirevic

Citation

Abstract
Background: Poor functional capacity is a predictor of higher morbidity and mortality in cardiac patients undergoing noncardiac surgery in general anesthesia. The objective of our prospective observational clinical study was to verify that the number of perioperative cardiologic complications significantly increased with the decline of functional capacity estimated by “Duke Activity Status Index” (DASI) criteria, in patients with angiographically verified coronary artery disease having undergone an open abdominal nonvascular surgery in general anesthesia. Design and Methods: The group of 111 consecutive patients was divided into three stratification subgroups according to DASI criteria, with poor 1<4MET 45(36.9%), moderate 4-7MET 43(38.7%) and good 7-10MET 23(20.7%) outcome. They were compared in relation to the incidence of perioperative cardiologic complications. During the surgery and in the following postoperative 72 hours, the patients were evaluated by continuous ST-T segment monitoring. 12-lead electrocardiogram was performed in all patients immediately after surgery, then on days 1, 2 and 7 after the operation and one day before their discharge. The patients were followed till the 30th postoperative day on daily basis. Results: Significant difference of the incidence of total mortality till the 30th postoperative day between three stratification subgroups according to DASI criteria was found in group I-5(11.1%) vs group II-1(2.3%) vs group III-0(0.0%) (p<0.05). Conclusions: History data obtained by DASI criteria were adequate evaluation of the functional capacity in coronary patients having undergone an open abdominal nonvascular surgery in general anesthesia. The incidence of perioperative cardiologic complications significantly increased with decline of the functional capacity evaluated by DASI criteria.

INTRODUCTION
The number of patients undergoing noncardiac surgery progressively increases worldwide and, according to the latest reference data, it is about 100 million a year.1 Out of a total number of patients, about 50% belong to the risk group, and approximately 5%-9% of patients experience perioperative major cardiologic complications (nonfatal myocardial infarction, nonfatal cardiac arrest and cardiac death).1 Comparison of cardiac patients with noncardiac subjects, in the similar type of surgery and anesthesia, revealed significantly higher percentage of all perioperative cardiologic complications.2 Lethal outcome of cardiac etiology in noncardiac surgery is reported in over 50% of cases of an overall perioperative mortality.3 On the first postoperative day, the mortality is four times higher in cardiac patients having undergone noncardiac surgery in comparison with general population of the same age and degree of cardiac risk, independently of surgical intervention.3 The patients with verified coronary artery disease account for about one-third of a total number of cases undergoing noncardiac surgery, on what basis the largest number of studies have evaluated the risk and perioperative cardiologic complications in coronary patients.

The objective of our prospective observational clinical study was:
To analyze perioperative cardiologic complications of coronary patients undergoing the open abdominal nonvascular surgery in general anesthesia;
To verify that the number of perioperative cardiologic complications significantly increases with decline of functional capacity estimated by “Duke Activity Status Index” (DASI) criteria;
To prove the significant difference of the incidence of perioperative minor, major and fatal cardiologic complications between three stratification subgroups by DASI criteria.

DESIGN AND METHODS
STUDY POPULATION AND PROTOCOL
Our prospective observational clinical study included the group of 111 consecutive patients with angiographically verified coronary arterial disease, operated on at the Department of Digestive Surgery, Institute of Digestive System Diseases, Clinical Center of Serbia (tertiary level teaching hospital) in Belgrade, Serbia.

Clinical characteristics of the selected patients according to “Duke Activity Status Index” criteria are described in Table 1.

### Table 1. Clinical characteristics of selected patients according to “Duke Activity Status Index”.

<table>
<thead>
<tr>
<th>Clinical characteristics of selected patients</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>Total number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 MET</td>
<td>45 (40.5%)</td>
<td>43 (38.7%)</td>
<td>23 (20.7%)</td>
<td>111 (100%)</td>
</tr>
<tr>
<td>History of coronary artery disease (angiographically verified)</td>
<td>11 (9.9%)</td>
<td>5 (4.5%)</td>
<td>10 (9.0%)</td>
<td>17 (15.5%)</td>
</tr>
<tr>
<td>Vascular heart diseases</td>
<td>17 (15.3%)</td>
<td>8 (7.2%)</td>
<td>4 (3.6%)</td>
<td>29 (26.1%)</td>
</tr>
<tr>
<td>Inflammatory myocardial diseases</td>
<td>21.8%</td>
<td>10.9%</td>
<td>0.0%</td>
<td>32.7%</td>
</tr>
<tr>
<td>History of arrhythmias and conduction disturbances</td>
<td>29 (26.1%)</td>
<td>14 (12.0%)</td>
<td>5 (4.5%)</td>
<td>48 (43.2%)</td>
</tr>
<tr>
<td>History of renal failure chronic/acute</td>
<td>32.7%</td>
<td>2 (1.8%)</td>
<td>0.0%</td>
<td>5 (4.5%)</td>
</tr>
<tr>
<td>History of cerebrovascular accident</td>
<td>10 (9.0%)</td>
<td>5 (4.5%)</td>
<td>2 (1.8%)</td>
<td>17 (15.5%)</td>
</tr>
<tr>
<td>History of peripheral arterial disease</td>
<td>56.5%</td>
<td>21.8%</td>
<td>10.9%</td>
<td>87.2%</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>65.4%</td>
<td>32.7%</td>
<td>2 (1.8%)</td>
<td>110.9%</td>
</tr>
</tbody>
</table>

### Figure 1

Preoperative preparation, postoperative follow-up as well as perioperative medicamentous therapy was completed according to American College of Cardiology/American Heart Association (ACC/AHA) 2002 Guidelines.4
Within preoperative preparation, the patients had complete physical, medical and cardiological examinations, and depending upon associated diseases, other specialist and subspecialist examinations. All patients underwent preoperative electrocardiogram (Schiller AT-1, Schiller Corp, Austria), chest and lung X-ray (Shimadzu RS 50 A, Shimadzu Corp, Kyoto, Japan), transthoracic echocardiography (Siemens Sequoia 256, Siemens Corp, Mountain View, CA) and complete laboratory analyses (Olympus 400, Olympus, Tokyo, Japan).

Criteria to enter the study included coronary artery disease verified angiographically. All patients from the selected group underwent coronary angiography in preoperative, prehospital period, irrelevantly of noncardiac surgery along with cardiosurgical consultation decision on further treatment of coronary disease (myocardial revascularization - coronary artery bypass grafting or medicamentous therapy - beta blocker, aspirin, statin). Angiographically verified severe stenosis (equal or over 75% of the blood vessel stenosis) of the coronary arteries and indication for coronary artery bypass grafting were found in 55 (49.5%) patients. Mild stenosis (less than 75% of blood vessel stenosis) of the coronary arteries with recommendation for beta blocker, aspirin, and statin therapy was detected in 56 (50.4%) patients. The group of consecutive patients without performed coronary angiography was excluded from the study, because their coronary disease was diagnosed only by medical history, without any former diagnostic tests.

The patients were divided into three stratification subgroups by “Duke Activity Status Index” criteria, released under the title “A brief self-administered questionnaire to determine functional capacity” by M.A. Hlatky in “American Journal of Cardiology” in 1989.5 (see Table 2).

Table 2 illustrates the original of “A brief self-administered questionnaire to determine functional capacity” - “Duke Activity Status Index” by M.A. Hlatky in 1989.5

The questionnaire contains four groups of questions related to physical capacity of patients for executing daily activities, which determine patient’s functional status. Functional status has been shown to be reliable for perioperative and long-term prediction of cardiac events. If the patient has not had a recent exercise test, functional status can usually be estimated on the basis of ability to perform daily activities. Functional capacities can be expressed in metabolic equivalent (MET) levels; the oxygen consumption (VO2) of a 70 kg 40-year old man in a resting state is 3.5 ml per kg per minute or 1 MET. For this reason, the functional capacity has been classified as excellent (higher than 10 METs), good (7-10 METs), moderate (4-7 METs), poor (less than 4 METs), or unknown. Perioperative and long-term risks are increased in patients unable to meet a 4 MET demand during common daily activities. Ergometric treadmill measurements inducing the ischaemia at low level exercise (<5 MET or heart rate > 100 min) identifies a high risk group, whereas the achievement of more than 7 MET (or heart rate >130) without ischemia identifies a low risk group. (See Table 3.)

Table 3 presents distribution of the selected patients by stratification groups according to “Duke Activity Status Index” criteria.
**PERIOPERATIVE MANAGEMENT - RISK REDUCTION STRATEGY**

Perioperative monitoring and medicamentous therapy were carried out in line with American College of Cardiology/American Heart Association (ACC/AHA) guidelines published in 2002.  

Coronary patients were monitored by continuous electrocardiogram during the surgery as well as in the immediate postoperative 72-hour period in the Intensive Care Unit, which recorded blood pressure and frequency values every hour, all kinds of electrocardiographic changes as well as saturation. All patients had 12-lead electrocardiography immediately after the surgery, and on postoperative days 1, 2 and 7 as well as a day before discharge from hospital. Cardiac biomarkers (CKMB and troponin) were evaluated at 6 h, 24 h and 96 hours following the surgery according to ACC/AHA 2002 recommendations.  

Coronary patients were monitored on daily basis during their stay in hospital and upon discharge till the 30th postoperative day. During hospitalization, all patients were observed by cardiologist every day.  

Coronary artery bypass grafting prior to open abdominal nonvascular surgery was performed in 7 (6.3%) patients of the subgroup I, in 20 (18.0%) patients of the subgroup II, and in 7 (6.3%) patients of the subgroup III. Indicated revascularization was not performed in 21 patients, because of the urgent surgery and/or poor general health status. In patients who were indicated for coronary revascularization, timing of the procedure depended on the emergency of noncardiac surgical procedure balanced against stability of the underlying coronary artery disease.  

Perioperative medicamentous beta blocker therapy was applied in 30 (27.0%) patients of the subgroup I, in 35 (31.5%) patients of the subgroup II, and in 18 (16.2%) patients of the subgroup III. Indicated beta blocker therapy was not employed in 28 (25.2%) coronary patients because the drugs were contraindicated.  

The following contraindications for beta-blocker therapy were analyzed: chronic/acute - hypotension, bradycardia, AV block II-III, heart failure and bronchospasm.  

All 111 coronary patients were indicated for perioperative beta-blocker application according to type and number of risk factors. One group of patients was covered by long-term chronic beta-blocker therapy in preoperative prehospital period, and the second group of patients had no therapy. In therapy group, beta-blocker was discontinued in one subgroup of patients due to sudden occurrence of contraindications to the respective drug, and other patients continued to take it. In non-therapy group without beta-blocker in preoperative prehospital period, beta-blocker was introduced in one subgroup of patients while others were not administered the drug because of already known contraindications to drug. (See Table 4)  

Aspirin was discontinued 3 days before planned surgery, and re-introduced into therapy on postoperative day 4. Low molecular weight heparin in prophylactic doses was applied twice a day in all patients before and after surgery.  

No patient was covered by statin therapy.  

Table 4 shows perioperative management - risk reduction strategies in selected patients (with severe stenoses) according to “Duke Activity Status Index” criteria.
Figure 4
Table 4. Perioperative management - Risk reduction strategy in coronary patients.

<table>
<thead>
<tr>
<th>Duke Activity Status Index</th>
<th>Severe stenosis</th>
<th>Myocardial revascularization</th>
<th>Beta-blocker</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Poor</td>
<td>26 (59.1%)</td>
<td>7 (6.3%)</td>
<td>30 (27.0%)</td>
</tr>
<tr>
<td>1-4 MET 44 (36.9%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II Moderate</td>
<td>20 (18.0%)</td>
<td></td>
<td>35 (16.2%)</td>
</tr>
<tr>
<td>4-7 MET 43 (38.7%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Good</td>
<td>8 (34.5%)</td>
<td>7 (6.3%)</td>
<td>18 (16.2%)</td>
</tr>
<tr>
<td>7-10 MET 23 (20.7%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of patients</td>
<td>55 (49.5%)</td>
<td>34 (30.6%)</td>
<td>83 (74.8%)</td>
</tr>
</tbody>
</table>

PERIOPERATIVE CARDIAC COMPLICATIONS
The following perioperative cardiologic complications were observed:

Minor perioperative cardiac complications:
- Hypertension (BP>160/100 mmHg, Class II JNC VII) - according to criteria of the Joint National Committee;
- Newly developed benign cardiac arrhythmias and conduction disturbances (sinus tachycardia HR>100bpm, supraventricular tachyarrhythmias, atrial fibrillation with rapid ventricular response, isolated premature ventricular contractions, nonsustained ventricular tachycardia, newly developed block of the branch right/left and AV block I and II) - documented by 12-lead electrocardiography and/or Holter electrocardiography;
- Transient myocardial ischemia with or without chest pain (transient and/or repeating ST ≥ 2mm in leads V1,V2,V3, ≥ 1 mm in the other leads, ST ≥ 1 mm in at least 2 adjoining leads, and/or symmetric inversion T waves ≥ 1 mm); 8

Major perioperative cardiac complications:
- Newly developed malignant cardiac arrhythmias and conduction disturbances (sustained ventricular tachycardia, ventricular fibrillation, and AV block IIIb)-documented by 12-lead electrocardiography and/or Holter electrocardiography;
- Nonfatal myocardial infarction (ESC/ACC 2000);8
- Nonfatal pulmonary edema - according to “Framingham Criteria for Heart Failure;”9
- Nonfatal cardiac arrest.
- Fatal perioperative cardiac complications were:
  - Cardiac death to the 30th postoperative day;
  - Cardiac/noncardiac death to the 30th postoperative day;
  - Cardiac/noncardiac death 30 days after surgery;

STATISTICAL ANALYSIS
The group of 111 consecutive patients with angiographically verified coronary artery disease was divided into three stratification subgroups according to DASI criteria.

Subgroup I included patients with poor 1<4 MET 45 (36.9%), subgroup II enrolled patients with moderate 4-7MET 43 (38.7%) and subgroup III consisted of patients with good 7-10MET 23 (20.7%) functional status.

Three subgroups of patients were compared in relation to minor, major and fatal perioperative cardiac complications.

A non-parametrical Pearson’s hi-square test using contingency tables was used to analyze the data from two groups with the level of significance set at 95% (p<0.05).

RESULTS
Our prospective observational clinical study analyzed perioperative cardiological complications in the group of 111 consecutive coronary patients having undergone an open abdominal nonvascular surgery under general anesthesia, divided into three stratification subgroups according to DASI criteria: poor 1<4 MET 45 (36.9%), moderate 4-7 MET 43 (38.7%) and good 7-10 MET 23 (20.7%).

A total number of patients with perioperative cardiologic complications in all three stratification groups was 59.5% (66/111) and 40.5% (45/111) patients had no cardiologic complications. A total number of minor, major and fatal
perioperative cardiologic complications was 132. The patients from the group < 4 MET had 84/132 (63.6%) cardiologic complications, from the group 4-7 MET had 38/132 (28.8%), and from the group 7-10 MET had 10/132 (7.6%) cardiologic complications (p<0.01).

The most common cardiologic complication was hypertension 42.3% (47/111) and the least frequent was the acute myocardial infarction, i.e. 4.5% (5/111).

A total number of patients with lethal outcome cardiac/noncardiac etiology to the 30th postoperative day was 5/111 (4.5%), and after the 30th postoperative day was 6/111 (5.4%). The number of patients with lethal outcome cardiac etiology to the 30th postoperative day was 3/111 (2.7%) and noncardiac etiology was 2/111 (1.8%), (see Table 5.)

The main result of our study was: significant difference of the incidence of total cardiac/noncardiac mortality till the 30th postoperative day between these three stratification subgroups (p<0.05).

The study also found significant difference of the expected perioperative cardiologic complications between these three stratification subgroups, as follows:

- hypertension (p<0.05),
- newly developed arrhythmias and conduction disturbances (p<0.01),
- transient myocardial ischemia (p<0.01),
- newly developed heart failures (p<0.05),
- the number of patients with major cardiologic complications (p<0.05),
- a total number of patients with perioperative cardiologic complications (p<0.01),
- a total number of perioperative minor, major and fatal cardiologic complications (p<0.01),
- and the number of patients assisted by mechanical ventilation (p<0.01).

The study failed to establish the significant difference of the incidence of the acute myocardial infarction (p>0.05) and cardiac death till 30th postoperative day (p>0.05), but it proved that the proportion of perioperative cardiologic complications increased with decline of the functional capacity according to DASI criteria.

Table 5 presents classification of patients according to “Duke Activity Status Index” in relation to perioperative minor, major and fatal cardiologic complications.
Table 5. Classification of patients according to “Duke Activity Status Index” in relation to perioperative minor, major and fatal cardiologic complications

<table>
<thead>
<tr>
<th></th>
<th>Duke Activity Status Index</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>Total number of cardiologic complications</td>
<td>p value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;4 MET</td>
<td>4-7 MET</td>
<td>7-10 MET</td>
<td>n=45</td>
<td>n=45</td>
<td>n=23</td>
</tr>
<tr>
<td>Hypertension</td>
<td>23</td>
<td>19</td>
<td>5</td>
<td>47</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>BP&gt;140/100 mmHg</td>
<td>31.1%</td>
<td>44.2%</td>
<td>21.7%</td>
<td>42.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinus tachycardia</td>
<td>16</td>
<td>10</td>
<td>1</td>
<td>27</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>HR&gt;100 bpm</td>
<td>35.5%</td>
<td>23.2%</td>
<td>4.3%</td>
<td>24.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newly developed arrhythmias and conduction disturbances</td>
<td>13</td>
<td>4</td>
<td>2</td>
<td>19</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Transient myocardial ischemia</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Acute myocardial infarction ESC/ACC</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Newly developed heart failure</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Cardiac death until the 30th postoperative day</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Total death cardiac/noncardiac until the 50th postoperative day</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Total death cardiac/noncardiac 30 days following surgery</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Total number of patients with cardiologic complications</td>
<td>34</td>
<td>24</td>
<td>8</td>
<td>66</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Number of patients with major cardiologic complications</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

Our prospective observational clinical study included the group of 111 consecutive patients with angiographically verified coronary arterial disease having undergone an open abdominal nonvascular surgery in general anesthesia.

Preoperative preparation, postoperative follow-up as well as perioperative medicamentous therapy was completed according to American College of Cardiology/American Heart Association (ACC/AHA) 2002 Guidelines.4

The group was divided into three stratification subgroups according to DASI criteria, group I - with poor 1–4 MET 45 (36.9%), group II - moderate 4–7 MET 43 (38.7%) and group III - good 7–10 MET 23 (20.7%) outcome. They were compared in relation to the incidence of minor, major and fatal perioperative cardiologic complications.

The objective of our study was to prove that the number of all expected perioperative cardiologic complications was significantly increased with decline of the functional capacity evaluated by DASI criteria.

During the surgery as well as in the following postoperative 72 hours, the patients were evaluated by continuous ST-T segment monitoring. 12-lead electrocardiogram was performed in all patients immediately after surgery, then on days 1, 2 and 7 after the operation and one day before their discharge. The patients were followed until the 30th postoperative day on daily basis.

The main result of our study was significant difference of the incidence of total cardiac/noncardiac mortality till the 30th postoperative day between these three stratification subgroups. The study also found significant difference of the incidence of total perioperative minor, major and fatal cardiologic complications between these three stratification subgroups.

The study established that the incidence of all expected perioperative cardiologic complications significantly increased with decline of the functional capacity.

The largest number of perioperative cardiologic complications was in the group of patients with poor functional capacity 1-4 MET, followed by the group with moderate functional capacity 4-7 MET and the least was in the group with excellent functional capacity 7-10 MET.

The incidence of lethal outcome of cardiac etiology to the 30th postoperative day was 3/111 (2.7%). The acute myocardial infarction, congestive heart failure and malignant arrhythmias (ventricular tachycardia and ventricular fibrillation), were direct causes of cardiac death in all three patients. Elevated troponin-T level over 1.0 micro g/l after surgery had 4 patients with poor functional capacity 1-4 MET, and 1 patient with moderate functional capacity 4-7 MET. One patient died on day 2, and other two on postoperative day 3. Cardiac cause of death was confirmed by postmortem examination. They all belonged to stratification group with poor functional capacity DASI of 1-4 MET.

We concluded that poor functional capacity DASI of 1-4 MET was a predictor of higher perioperative morbidity and mortality in cardiologic patients undergoing the open abdominal nonvascular surgery in general anesthesia. A significant correlation between severe stenoses and DASI was found.

Since 1989 until present, a total of 107 studies have used DASI for assessment of functional capacity of cardiac patients as well as other surgical and non-surgical patients.10-23 The index was proven worth for evaluation of stress tolerance before and after all kinds of surgical interventions as well as independently of surgery. 10-23 Given it is an equivalent of treadmill stress test, it is highly significant for risk evaluation in cardiac patients in noncardiac nonvascular surgery.6

So far, no study using DASI for estimation of functional capacity in patients with angiographically verified coronary artery disease having undergone an open abdominal nonvascular surgery in general anesthesia has been ever published. For this reason, the results of this study cannot be directly compared with the results of the earlier studies.

CONCLUSIONS

The study established the following:

Significant difference of the incidence of total mortality till the 30th postoperative day between three stratification subgroups according to DASI criteria: group I–5 (11.1%) vs group II-1 (2.3%) vs group-III–0 (0.0%) (p<0.05);

The incidence of minor, major and fatal perioperative cardiologic complications significantly increased with decline of functional capacity evaluated by DASI criteria (p<0.01);

Significant difference of the incidence of perioperative minor, major and fatal cardiologic complications between
three stratification subgroups by DASI criteria (p<0.01);

History data obtained according to DASI criteria were an adequate evaluation of functional capacity of patients with angiographically verified coronary artery disease having undergone an open abdominal nonvascular surgery in general anesthesia.

References
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