Kardiologia Polska 2018; 76, 4: 797–799; DOI: 10.5603/KP.2018.0078 ISSN 0022–9032

SHORT COMMUNICATION

Pre-discharge test may worsen cognitive functioning in patients with implantable cardioverter-defibrillator

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INTRODUCTION

The most effective method of termination of malignant ventricular arrhythmias is the implantation of a cardioverter-defibrillator (ICD). Sometimes, to verify proper functioning of the ICD, a pre-discharge test (PT) is conducted [1, 2]. While evaluation of the clinical benefits and risks of the PT has been the subject of many previous studies [3–5], the number of studies on the PT's possible impact on cognitive functioning is low. This effect is potentially possible due to PT-induced ventricular fibrillation and cardiac arrest, which cause short-term but evident brain ischaemia. There is therefore a possibility of temporary or even permanent impairment of cerebral functions.

The aim of this study was to evaluate the potential influence of short-term PT-induced cardiac arrest on cognitive functions, such as episodic memory, learning, working memory capacity, spatial recognition, visual recognition, response orientation, and rule acquisition, in ICD patients.

METHODS

The study included consecutive patients admitted to the Department of Cardiology and Electrotherapy of the Medical University of Gdansk between June 2014 and October 2015. The basic inclusion criteria were ICD implantation and qualification for PT by an attending cardiologist (patients were qualified for PT when they had an ICD due to secondary prevention, when the device was implanted on the right side, and when there was an indication for ICD replacement).

Exclusion criteria comprised the presence of consciousness disorders (disturbances in the allo- and autopsychic orientation) during the study, documented mental retardation, paresis due to past ischaemic and/or haemorrhagic stroke, severe cardiological or general condition preventing from participation in the study, and lack of the patient's consent to participate in the research.

In each patient, the psychological tests planned in this work were carried out twice: before and after the PT (before the patient was discharged from hospital, at least 24 h after PT).

A detailed description of psychological tests

Cambridge Neuropsychological Test Automated Battery (CANTAB) technology was used. In this technology all tests are carried out automatically on a touch screen, and the script for the researcher provides a standardised test instruction, which increases test reliability.

Motor Screening Task (MOT) is a training test aimed at relaxing the tested person and familiarising him/her with the computer and touch screen. The test is used at the beginning of the study. It evaluates possible difficulties with seeing, movement, and understanding commands.

Pattern Recognition Memory (PRM) is a test of visual recognition. The examined person is initially presented with 15 patterns that appear on the screen one by one. Subsequently, the subject is asked to choose, among two possibilities, the pattern that was previously shown.

Spatial Recognition Memory (SRM) is a spatial recognition test. The subject's task is to remember the location of separately presented squares (five squares in total in a series) and then choose from two squares the one that was previously shown in a given place.

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Received: 17.12.2017 **Accepted:** 09.02.2018

Table 1. The results of tests examining cognitive functions before and after the predischarge test (PT)

	Before PT (n = 22)	After PT (n = 22)	p
MOT — mean error	11.625 ± 2.4 (6.36–15.82)	12.787 ± 2.467 (9.56–17.72)	0.058
PRM — number correct	17.818 ± 2.872 (12–22)	17.182 ± 3.231 (10–21)	0.165
PRM — per cent correct	74.242 ± 11.969 (50–91.67)	71.592 ± 13.463 (41.67–87.5)	0.191
SRM — number correct	14 ± 2.582 (7–17)	13.273 ± 3.383 (7–18)	0.409
SRM — per cent correct	70 ± 12.91 (35–85)	66.364 ± 16.916 (35–90)	0.409
PAL — total errors (adjusted)	47.5 ± 34.184 (10–115)	60.909 ± 35.161 (11–124)	**< 0.019**
PAL — mean error to success ratio	4.84 ± 2.86 (1.25–10.57)	10.88 ± 6.23 (1.38–21)	**< 0.0009**
PAL — stages completed	7.46 ± 0.8 (6–8)	5.14 ± 1.67 (3–8)	**< 0.0004**
SSP — stages completed	4.77 ± 1.11 (3–7)	5 ± 1.35 (3–7)	0.248
SSP — total errors	11.64 ± 3.259 (5–17)	13.5 ± 6.03 (6–26)	0.117
SSP — number of attempts	7.36 ± 1.59 (5–11)	8.09 ± 2.05 (5–11)	**< 0.039**
IED — total errors adjusted	42.36 ± 37.24 (11–184)	56.09 ± 45.78 (8–179)	0.192
IED — stages completed	7.96 ± 1.59 (2–9)	7.64± 1.99 (2–9)	0.647

Data are shown as mean ± standard deviation (SD) and minimum–maximum. MOT — Motor Screening Task; PRM — Pattern Recognition Memory; SRM — Spatial Recognition Memory; PAL — Paired Associates Learning; SSP — Spatial Span; IED — Intra/Extradimensional Set Shift

Paired Associates Learning (PAL) is a test that examines visual memory and learning. In the test, six boxes appear on the screen, and they open in a random order. Some of them contain a pattern, others are empty. The task of the examined person is to remember which box contained the pattern. The number of boxes with a pattern inside increases (until there is a pattern in each box — six patterns in total). After "opening" all boxes, one of the patterns is presented in the middle of the screen, and the task of the examined person is to indicate which box it was originally contained in. If the tested person correctly assigns each box to a pattern, then we move to the last stage of the test, in which the number of boxes containing patterns increases to eight.

Spatial Span (SSP) is a test examining the capacity of working memory. In this task nine boxes that change colour in a specific order are scattered on the screen. The task of the subject is to remember and repeat the order in which the change of colour occurred.

Intra/Extradimensional Set Shift (IED) is a test examining the ability to understand rules (rule acquisition) and their reversal. This test assesses flexibility and the ability to sustain attention and maintain response orientation. At the beginning of the test, simple stimuli (shapes) are presented to the examined person. Then, complex stimuli (coloured shapes and white lines) are shown. The task of the subject is to find the rule established by the computer which indicates that the pattern is correct [6].

Statistical analysis

Statistical analysis was performed using STATISTICA 10. The values were given as mean ± standard deviation (minimum–maximum) or number (percentage). The Wilcoxon signed-rank test was used to assess the changes between the first and second examination. A p value ≤ 0.05 was considered statistically significant.

RESULTS

Thirty patients were included in the study, but eight were excluded in the process: three patients withdrew their consent, two were discharged before the second examination, two changed the PT date, and one presented reduction of psychomotor efficiency preventing participation in the tasks. A total of 22 patients (mean age 63 ± 16 years; 13 men) were included in the final analysis. Left ventricular ejection fraction was 28% ± 7%. The results of the psychological assessment are presented in Table 1.

DISCUSSION

The most important finding of this study is that PT performed after ICD implantation has a significantly negative impact on cognitive functions, such as episodic memory, learning, and working memory capacity. Tendencies to deteriorate were also reported in spatial recognition, visual recognition, response orientation, and rule acquisition, although these differences were not statistically significant.

There have been few publications regarding changes in the cognitive functioning of patients after the PT. They differ from our study in the number [7–9] or age of patients [7] and the methodology of psychological tests [7, 8], and some of them assessed changes in cognitive functions induced by other factors [10–12].

Adams et al. [7], for example, did not report PT-induced deterioration of cognitive functions, however the results could have been influenced by significantly lower age of the studied patients. Additionally, the two studies differ in the methodo-

logy. Adams et al. [7] used, among others, the trail making test, finger tapping test, and the Mini-Mental test, whereas in our study the CANTAB tests were applied. Different tests, including the method of result recording, time measurements, and the assumed cut-off point on the basis of which the presence or absence of pathology was established, could have caused discrepant results.

The results of the study by Murkin et al. [8] were similar to ours, but the study group in that paper was smaller and the mean age was lower. Also, discrepancies in the methods used should be taken into consideration [8]. The question arises whether the results of repetitive digit and digit symbol tests performed over a short period of time could have been negatively affected by patients memorising the sequences. In contrast, our study used the parallel version of the test, which excluded such a possibility.

The study conducted by Hallas et al. [12] assessed the impact of ICD implantation itself on cognitive functions. The implantation is performed without compromising the cerebral flow; therefore, the impairment of cognitive functions after this intervention is not likely to occur.

Interesting results have been published by Buanes et al. [10]. Using the CANTAB tests, the authors reported, similarly to our results, a reduction of the efficiency of learning as well as visual and spatial memory, but they did not observe deterioration of executive functions in patients after spontaneous cardiac arrest. Of course, the effectss of PT-induced and out-of-hospital cardiac arrest on cognitive functioning are different. In the latter situation, the incident takes place under uncontrolled conditions and health consequences may be much more serious. For obvious reasons, there are no data on the cognitive functioning of patients before cardiac arrest. Furthermore, Buanes et al. [10] examined patients about four years after the occurrence of cardiac arrest, while the present work showed the results obtained immediately after the PT procedure. Other authors [11] who investigated patients after out-of-hospital cardiac arrest in the period of more than two months after the incident observed, similarly to our results, deterioration in delayed recall and spatial and verbal memory.

In conclusion, in the assessed group of patients with an implanted ICD, PT carried out before discharge from hospital led to a decrease in cognitive functioning, such as episodic memory, learning, and the capacity of working memory, observed shortly after the test. Persistence of cognitive impairment and evaluation of long-term effects requires further examination.

Conflict of interest: *none declared*

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Cite this article as: Raczak A, Daniłowicz-Szymanowicz L, Kempa M, et al. Pre-discharge test may worsen cognitive functioning in patients with implantable cardioverter-defibrillator. Kardiol Pol. 2018; 76(4): 797–799, doi: 10.5603/KP.2018.0078.