Autonomic Neuroscience: Basic and Clinical 160 (2011) 107–114

Contents lists available at ScienceDirect

Autonomic Neuroscience: Basic and Clinical

journal homepage: www.elsevier.com/locate/autneu

Effects of emotional excitement on heart rate and blood pressure dynamics in patients with coronary artery disease

Olli-Pekka Piira [a], Heikki V. Huikuri [a], Mikko P. Tulppo [a,b,*]

[a] Institute of Clinical Medicine, Department of Internal Medicine, University of Oulu, Finland
[b] Department of Exercise and Medical Physiology, Verve Research, Verve, Oulu, Finland

ARTICLE INFO

Article history:
Received 7 October 2010
Received in revised form 24 November 2010
Accepted 24 November 2010

Keywords:
Autonomic regulation
Sympathetic activity
Coronary artery disease

ABSTRACT

The incidence of adverse cardiovascular events is higher among spectators of exciting sports events, but the mechanistic link between the events is not known. We assessed the heart rate (HR) and blood pressure (BP) dynamics of enthusiastic male ice hockey spectators (60 ± 9 years) with coronary artery disease (CAD) during Finnish national league ice hockey play-off final matches. Twenty-four-hour ambulatory ECG ($n = 55$) and BP ($n = 17$) were recorded at the time of the match and on a control day. Beat-to-beat R–R intervals and BP were recorded during the match and a bicycle exercise at equal HR levels ($n = 21$). Systolic and diastolic BP were significantly higher 1 h before, during, and 1 h after the match than on the control day, e.g., the highest systolic BP was 180 ± 14 vs. 145 ± 15 and diastolic 103 ± 13 vs. 82 ± 11 mmHg ($p<0.001$ for both). HR was higher throughout the match ($p<0.05$) and remained elevated 2 h after the match ($p<0001$), and measures of HR variability were decreased during the match ($p<0.01$). Low-frequency variability in BP was higher during the match than during the exercise test ($p<0.01$). The results show that cardiac vagal outflow is attenuated and vasomotor sympathetic activity elevated during exciting sports events and BP dynamics differ from those occurring during physical exercise at equal HRs. The autonomic reactions may partly explain the vulnerability to cardiovascular events caused by this type of leisure-time emotional excitement.

1. Introduction

Environmental stress has been shown to be an important risk factor for cardiovascular events (Strike and Steptoe, 2003; Steptoe and Brydon, 2009). Epidemiological data show earthquakes, war, and sporting events cause a peak in the incidence of cardiovascular events (Meisel et al., 1991; Leor et al., 1996; Serra Grima et al., 2005). Recently, Wilbert-Lampen et al. showed that a stressful soccer game more than doubled the risk of acute cardiovascular events, including acute coronary syndrome and symptomatic cardiac arrhythmia, during a World Cup Soccer match held in Germany in 2006 (Wilbert-Lampen et al., 2008). On those days, the highest average incidence of events was observed during the first 2 h after the beginning of each match. Carroll et al., 2002 have shown an increase in the incidence of acute myocardial infarction after the national team lost a penalty shoot-out (Carroll et al., 2002). Previous studies have also shown that triggering is more common in patients with coronary artery disease than without it (Leor et al., 1996; Strike et al., 2006a,b; Tofler and Muller, 2006). Some studies have also found that most of the additional cardiac emergencies occur in men, explained by sex-specific pathophysiological differences and/or interest in sports or vulnerability to emotional triggers (Tofler et al., 1990; Witte et al., 2000; Culic et al., 2003).

The mechanisms by which emotional excitement, such as watching sports events, increases vulnerability to untoward cardiac events is not well known. At the moment, ice hockey is the most intensively followed sport in Finland, and national play-off finals are of great significance to a large proportion of the population, especially males. The aim of this study was to evaluate changes in autonomic regulation measured by heart rate (HR) variability and ambulatory blood pressure (BP) in enthusiastic ice hockey fans with coronary artery disease (CAD) during play-off ice hockey matches in Oulu, Finland, played by the Oulun Kärpät team in the spring of 2008 and 2009. The changes related to the hockey match were compared with control day measurements without any sports events. To further elucidate the autonomic responses to emotional excitement compared with physical exercise, simultaneous beat-to-beat BP, R–R intervals, and respiration were measured in a subgroup of subjects at baseline controlled conditions, during the ice hockey match, and during a bicycle exercise test.

2. Methods

2.1. Study protocol

The study included patients with stable coronary artery disease (CAD) who participated as spectators in the ice hockey play-off finals

* Corresponding author. Department of Exercise and Medical Physiology, Verve Research, Verve, P.O. Box 404, FI-90101 Oulu, Finland. Tel.: +358 40 508 1902; fax: +358 20 757 4702.
E-mail address: Mikko.Tulppo@verve.fi (M.P. Tulppo).

1566-0702/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.autneu.2010.11.011

of the Finnish National League played in the city of Oulu, Finland, during 2008 and 2009. The Oulun Kärpät team won the championship of the Finnish National Ice Hockey League in 2008 and ranked second in 2009. The measurements were performed in the ice hockey hall during all the play-offs, inside the full ice hockey hall among ~6000 other spectators, played in the city of Oulu ("home matches") in 2008 and 2009 (6 matches in 2008 and in 3 matches in 2009). The average number of monitored subjects in each match was 4±1 in 2008 and 10±1 in 2009, resulting in a total of 55 patients. The Oulun Kärpät team lost only one home match and 3 subjects where monitored during that match. Therefore, we were not able to study the effects of the result of the match on autonomic responses.

Twenty-four-hour ECG recording was performed for all the patients during the match day and during a control day within a one-week interval. Ambulatory BP measurements were performed for 17 patients during the match and the control day in 2009. Beat-to-beat BP, ECG, and respiration frequency were measured in 21 patients in Oulu University Hospital located next to ice hockey hall on the morning of the match day and during the match in the ice hockey hall in 2009. The next day the same recordings were performed (Oulu University Hospital) during a dynamic bicycle exercise test targeting HR at the same level as that measured during the match.

2.2. Patient selection

The CAD patients were selected from the ARTEMIS (Innovation to Reduce Cardiovascular Complications of Diabetes at the Intersection) study database. In the ARTEMIS study, patients with CAD have undergone a thorough evaluation of their cardiovascular status, including, e.g., a baseline examination done by a cardiologist, tissue Doppler echocardiography, an exercise stress test, and 24-h Holter recordings. CAD and its severity had been assessed by coronary angiography at Oulu University Hospital within six months of inclusion. To maximize the likelihood of emotional arousal during the ice hockey match, the candidates were interviewed by telephone according to a flow chart presented in Fig. 1. The characteristics of the patients are presented in Table 1. The study was performed according to the Declaration of Helsinki, and the local committee of research ethics of the Northern Ostrobothnia Hospital District approved the protocol, and all the subjects gave written informed consent.

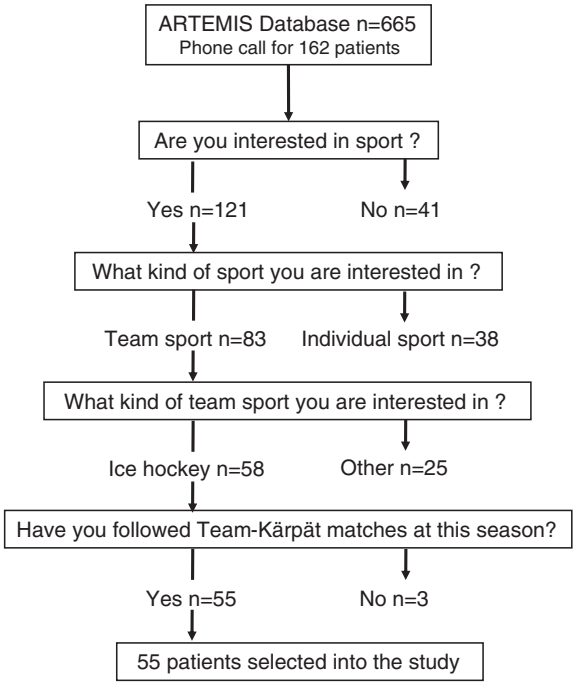

Fig. 1. The patient's selection protocol from ARTEMIS database.

Table 1
Characteristics of the study group.

	All	Ambulatory ECG	Ambulatory blood pressure	Beat-to-beat blood pressure
	$n=55$	$n=40$	$n=14$	$n=21$
Sex/male	55 (100%)	40 (100%)	14 (100%)	21 (100%)
Age (years)	60±10	60±9	60±9	58±11
BMI	29±4	29±4	28±4	29±4
Diabetes	23 (42%)	18 (46%)	7 (50%)	8 (42%)
Current smokers	3 (5%)	2(5%)	2 (14%)	2 (10%)
Sleep apnea	5 (9%)	4 (10%)	0	2 (10%)
Hypertension	33 (60%)	24 (60%)	7 (50%)	14 (67%)
History of AMI	26 (47%)	17 (43%)	7 (50%)	10 (48%)
Revascularized	47 (85%)	34 (85%)	13 (93%)	17 (81%)
CABG	19 (35%)	16 (40%)	7 (50%)	4 (19%)
PCI	31 (56%)	20 (50%)	7 (50%)	11 (52%)
Angina pectoris				
CCS Class 1	46 (83%)	35 (88%)	11 (79%)	15 (71%)
CCS Class 2	8 (15%)	4 (10%)	2 (14%)	5 (24%)
CCS Class 3	1 (2%)	1 (2%)	1 (7%)	1 (5%)
1-vessel CAD	18 (33%)	13 (33%)	2 (14%)	7 (33%)
2-vessel CAD	14 (25%)	7 (18%)	4 (28%)	5 (24%)
3-vessel CAD	23 (42%)	20 (50%)	8 (56%)	9 (43%)
EF	65±7.7	64±7	65±10	64±9
E´/E	10±4.1	11±4.3	9.2±2.5	9.1±4.3
LVH (echo)	19 (35%)	14 (35%)	5 (36%)	6 (29%)
Bicycle stress test				
max load(W)	169±40	166±36	160±38	172±43
METS	6,8±1.7	6,8±1.6	6.7±1.7	7.0±1.8
Max ST depression>1 mm	19 (33%)	15 (38%)	4 (29%)	5 (24%)
Max heart rate	135±20	135±20	135±22	132±19
Medication				
Aspirin	53 (96%)	38 (95%)	14 (100%)	21 (100%)
Clopidogrel	21 (38%)	12 (30%)	6 (43%)	8 (38%)
Warfarin	1 (2%)	1 (3%)	0	0
Beta Blockers	52 (95%)	38 (95%)	14 (100%)	21 (100%)
Bisoprolol	35 (67%)	24 (63%)	7 (50%)	15 (71%)
Metoprolol	16 (31%)	14 (37%)	7 (50%)	5 (24%)
Atenolol	1 (2%)	0	0	1 (5%)
Calcium antagonists	12 (22%)	8(20%)	1 (7%)	6 (29%)
ACEI/ARB	37 (67%)	28 (70%)	12 (86%)	18 (86%)
Diuretics	15 (27%)	11 (28%)	2 (14%)	5 (24%)
Statin	55 (100%)	40 (100%)	14 (100%)	21 (100%)
Insulines	6 (11%)	4 (10%)	1 (7%)	2 (10%)
Oral antidiabetics	16 (29%)	11 (28%)	3 (21%)	4 (19%)
Nitrates	14 (25%)	9 (23%)	5 (36%)	2 (10%)

Values are means ± SD; BMI; body mass index, diabetes (all were type 2 diabetes), AMI; acute myocardial infarction, revascularized; the patients who had at least one of the procedures (CABG coronary artery by-bass grafting or PCI percutaneus coronary intervention) EF; Ejection Fraction; E´/E basal septal E`with tissue Doppler ratio to mitral inflow E wave, LVH left ventricular hypertrophy with ASE guidelines, CCS Canadian cardiology society functional class, CAD coronary artery disease; 1-, 2- and 3-CAD; angiografically evaluated proximal coronary arteries with more than 50% stenosis; ACEI angiotensin conversion enzymes inhibitor; ARB angiotensin receptor blocker; ACEI/ARB the patients using at least one of them.

2.3. Ambulatory 24-h ECG

Ambulatory ECG was recorded with a digital Holter recorder (Medilog AR12, Huntleigh Healtcare, UK) with an accuracy of 1 ms and saved on a computer for further analysis with custom-made software, as described earlier in detail (Huikuri et al., 1990, 1994) (HEARTS software Heart Signal Co, Kempele, Finland). First, HR variability was analyzed over the entire ice hockey match (3 h) and during the control measurement at the corresponding time of day (3 h). Second, HR variability indices that showed significant differences between the match and control measurements were analyzed in 1-h periods before, during, and after the match and on the control days to reveal more accurate temporal changes in these indices. Seven