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Anxiety sensitivity predicts increased perceived exertion during a 1-mile walk test among treatment-seeking smokers

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Abstract Smoking increases risk of early morbidity and mortality, and risk is compounded by physical inactivity. Anxiety sensitivity (fear of anxiety-relevant somatic sensations) is a cognitive factor that may amplify the subjective experience of exertion (effort) during exercise, subsequently resulting in lower engagement in physical activity. We examined the effect of anxiety sensitivity on ratings of perceived exertion (RPE) and physiological arousal (heart rate) during a bout of exercise among low-active treatment-seeking smokers. Adult daily smokers (n = 157; $M_{age} = 44.9$, $SD = 11.13$; 69.4% female) completed the Rockport 1.0 mile submaximal treadmill walk test. RPE and heart rate were assessed during the walk test. Multi-level modeling was used to examine the interactive effect of anxiety sensitivity × time on RPE and on heart rate at five time points during the walk test. There were significant linear and cubic time × anxiety sensitivity effects for RPE. High anxiety sensitivity was associated with greater initial increases in RPE during the walk test, with stabilized ratings towards the last 5 min, whereas low anxiety sensitivity was associated with lower initial increase in RPE which stabilized more quickly. The linear time × anxiety sensitivity effect for heart rate was not significant. Anxiety sensitivity is associated with increasing RPE during moderate-intensity exercise. Persistently rising RPE observed for smokers with high anxiety sensitivity may contribute to the negative experience of exercise, resulting in early termination of bouts of prolonged activity and/or decreased likelihood of future engagement in physical activity.

Keywords RPE · Anxiety · Tobacco · Aerobic exercise · Physical activity

Introduction

Approximately one in two adults in the United States is living with one or more chronic diseases (e.g., obesity, cancer, coronary heart disease, diabetes; Centers for Disease Control and Prevention, 2013; Ward et al., 2014). Collectively, these diseases contribute significantly to the national health burden, including disability, early mortality, and increased healthcare costs (U.S. Burden of Disease Collaborators, 2013). Cigarette smoking is a major risk factor for many chronic diseases and remains the leading cause of preventable morbidity and mortality in the United States (Centers for Disease Control and Prevention, 2015).

There is clear evidence that physical activity reduces risk of early morbidity and mortality (Office of Disease Prevention and Health Promotion, 2014; U.S. Department of Health and Human Services, 2008, 2015). However, more than half of adults in the United States do not meet the federal guidelines for aerobic exercise (53.9%; Centers for Disease Control and Prevention, 2013), and as low as 10% meet these guidelines when objective assessments of physical activity are used (Tucker et al., 2011). Moreover, the combination of physical inactivity and cigarette smoking compounds risk for disability and early mortality

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(Borrell, 2014; Shaw & Agahi, 2014; Stenholm et al., 2016). As a result, there is increasing scholarly interest in promotion of physical activity as a way to aid smoking cessation (Ussher et al., 2014) and simultaneously recognition of the need to identify barriers to engagement in physical activity.

One psychological factor that may interfere with physical activity engagement is anxiety sensitivity. Anxiety sensitivity is defined as the extent to which individuals attend to and believe that anxiety and anxiety-related sensations such as racing heart, sweating, or dizziness have harmful consequences (McNally, 2002; Reiss, 1991; Taylor, 1995). Anxiety sensitivity acts as an amplifier of negative affective and physiological states (Asmundson & Norton, 1995; McCracken & Keogh, 2009; Zvolensky et al., 2014), such that the fear of anxiety and arousal sensations can exacerbate the actual subjective experience of these distress states. Additionally, anxiety sensitivity is predictive of maladaptive coping and avoidance (Otto et al., 2016).

There is growing recognition that anxiety sensitivity is related to various unhealthy behaviors. Some of the most consistent data indicate that anxiety sensitivity is associated with various aspects of cigarette smoking (Leventhal & Zvolensky, 2015), including beliefs that smoking will reduce negative affect (Farris et al., 2015), more severe nicotine withdrawal symptoms during early phases of quitting (Johnson et al., 2012; Langdon et al., 2013), and poorer smoking cessation outcomes (Assayag et al., 2012; Zvolensky et al., 2009). Anxiety sensitivity is also linked to physical inactivity (Smits et al., 2010). Indeed, among community and clinical samples (non-smoking specific), anxiety sensitivity is negatively associated with exercise frequency and fitness levels (Goodin et al., 2009; McWilliams & Asmundson, 2001; Sabourin et al., 2011; Smits & Zvolensky, 2006), and predicts lower engagement in exercise (Hearon et al., 2014; Moshier et al., 2016). Moreover, specifically among sedentary treatment-seeking cigarette smokers, anxiety sensitivity is associated with lower cardiorespiratory fitness level measured during a graded submaximal exercise test (Farris et al., 2016).

Theoretically, individuals with elevated anxiety sensitivity may be unwilling to engage in physical activity due to the perceived dangerousness or harmfulness of the interoceptive sensations evoked during exercise (Smits et al., 2010). Perceptions of harm may in turn amplify the experience of these somatic sensations and emotional distress, thus producing aversion to exercise and subsequent avoidance of exercise (Otto et al., 2016). It is unknown how anxiety sensitivity is related to perceived exertion (subjective effort) during activity bout of aerobic exercise. Given higher ratings of perceived exertion during exercise are associated with physical inactivity (Williams et al., 2008) and anxiety sensitivity is associated with greater negative affect during exercise (Smits et al., 2010), it is possible that individuals with higher levels of anxiety sensitivity may perceive that they are exerting more effort during a during aerobic exercise, which could further contribute to the amplified experience of interoceptive distress and subsequent avoidance of physical activity.

The current study aimed to examine whether anxiety sensitivity was associated with ratings of perceived exertion (RPE) during a bout of aerobic exercise among a sample of low-active daily smokers seeking treatment for smoking cessation. Specifically, we hypothesized that smokers with higher levels of anxiety sensitivity would report greater RPE than smokers with lower levels during a submaximal exercise test. Additionally, as an exploratory aim, we examined the association between anxiety sensitivity and objective physiological arousal (i.e., heart rate; HR) during the test. These associations were expected to be observed beyond the contribution of level of tobacco dependence and sex.

Materials and methods

Participants and procedure

Data analyzed were collected as part of an ongoing randomized controlled smoking cessation trial for community-recruited treatment-seeking smokers with elevated depressive symptoms (clinicaltrials.gov #: NCT02086149).The trial is examining the efficacy of standard phone-based cognitive behavioral therapy (CBT) for smoking cessation and nicotine replacement therapy, with one of two adjunctive treatments: (1) 12-session, group aerobic exercise (AE) intervention or (b) 12-session, group health-education control (HEC) intervention. Inclusion criteria included: being between the ages of 18–65 years, smoking $\geq$10 cigarettes per day, engaging in less than 90 min per week of moderate-to-vigorous physical activity for the last 3 months, and a score of 6 or greater on the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). Participants were excluded from participation if: they met DSM-IV criteria for alcohol or drug abuse or dependence, eating disorder, or psychotic disorder; had current suicidality or homicidality; had physical disabilities or medical problems contraindicated for aerobic exercise; were currently pregnancy or intended to become pregnant in the next 3 months; or had current use of pharmacotherapy for smoking cessation (e.g., nicotine replacement therapy). Baseline assessment data were available from 157 participants ($M_{age} = 44.9$, $SD = 11.13$; 69.4% female). All of the measures presented in this manuscript are from the baseline assessment.

Measures

The Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007) is an 18-item psychometrically-sound self-report measure in which respondents indicate the extent to which they are concerned about possible negative consequences of anxiety-related symptoms (e.g., "It scares me when my heart beats rapidly"). Responses are rated on a five-point Likert scale ranging from 0 (very little) to 4 (very much) and summed to create a total score (possible range 0–72). The ASI-3 items have strong and improved psychometric properties relative to previously measured items of the construct (Taylor et al., 2007) and have strong documented psychometric properties in daily cigarette smokers, including factor stability, reliability (test–retest, internal consistency), known-group validity, and convergent, discriminant, and predictive validity with key affective and smoking-relevant processes (Farris et al., 2015).

The Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991) is a 6-item self-report assessment of severity of tobacco dependence. Higher scores (possible range 0–10) reflect greater physiological dependence on tobacco. The Smoking History Questionnaire (SHQ; Brown et al., 2002) and Timeline Follow-Back (TLFB; Brown et al., 1998) were used to describe the sample in terms of smoking characteristics (e.g., age of smoking initiation, cigarettes per day).

Exercise testing was completed via the Rockport 1.0 mile treadmill walk test (Pober et al., 2002), a standardized submaximal exercise test. The 1-mile walk test was supervised and conducted by an exercise physiologist. During the 3–5 min warm-up period, the speed of the treadmill belt was gradually increased until participants chose the fastest walking speed that they believed could be maintained for one mile. The exercise physiologist encouraged participants to continue increasing speed until heart rate (HR) was at a target range for moderate-intensity physical activity (64–76% of age predicted maximal heart rate (American College of Sports Medicine, 2010). Average self-selected speed on the treadmill was 2.8 miles/h ($SD = 0.51$). HR was continuously monitored during the walk test using a Polar Heart monitor. The Borg Rating of Perceived Exertion (RPE) Scale (Borg, 1982) was used to assess subjective feelings of physical exertion and effort, including breathlessness and fatigue during the exercise test. Participants are instructed to rate their level of exertion at the moment on a scale from 6 (*no exertion at all*) to 20 (*maximal exertion*). Borg (1998) suggests that a person's RPE $\times$ 10 may roughly correspond to his/her actual HR during physical activity, although there are certainly several factors that may independently influence RPE and HR (e.g., age, fitness level). RPE was assessed by the exercise physiologist every 5 min starting at minute 2 once participants reached the set treadmill speed. HR was assessed at every minute during the walk test. HR at every 5 min were utilized in the current study to correspond with RPE. On average, participants provided 4.3 ($SD = 0.86$) RPE ratings during the walk test (observed range = 1–7). The first five RPE ratings during the walk test were used in analyses (ratings up to 22 min); the last two observed RPE ratings were not included in analyses due to low frequency (n = 12 cases).

Data analytic procedures

First, bivariate associations were examined between anxiety sensitivity, tobacco dependence, and average RPE and HR during the walk test. Second, multilevel modeling was used to examine the association between anxiety sensitivity and changes in RPE and HR during the walk test. Random intercepts and slopes were included in all models. An unstructured covariance matrix was specified to allow for each covariance to be uniquely estimated (StataCorp LP, 2015). Time was mean-centered to prevent multicollinearity when using higher-order polynomials (Aiken & West, 1991). Anxiety sensitivity was dichotomized based on a validated clinical cutoff on the ASI-3, with scores <17 reflecting low levels of anxiety sensitivity and scores $\geq$17 reflecting moderate or severe levels of anxiety sensitivity (Allan et al., 2014). Participant sex (coded 0 = male, 1 = female) and FTND were entered as model covariates. Pre-walk test HR was entered, where relevant. Significance was defined as $p < .05$.

Results

Participants (n = 157) were primarily white (82.2%) and non-Hispanic (95.5%); 65.4% completed at least some college. The sample had moderate levels of tobacco dependence according to the FTND ($M = 5.5$, $SD = 2.01$; range = 0–10) and smoked an average of 19.5 ($SD = 8.69$) cigarettes per day. The sample averaged moderate levels of anxiety sensitivity on the ASI-3 ($M = 14.4$, $SD = 13.84$; range = 0–58), and 31.8% had ASI-3 scores $\geq$17, indicating elevated levels of anxiety sensitivity (Allan et al., 2014). Zero-order correlations were examined between study variables (see Table 1). Bivariate associations revealed significant positive associations between ASI-3 with both FTND scores and female sex. Female sex was also associated with higher average HR during the walk test and lower speed during the walk test.

Two multi-level model analyses were conducted to examine whether anxiety sensitivity was related to changes in RPE and HR during the course of the walk test. See

Table 1 Descriptive characteristics and bivariate associations between study variables

Variable	1.	2.	3.	4.	5.	6.
1. Gender	–	.161*	−.059	.023	.243**	−.314**
2. ASI-3		–	.191*	.089	−.058	−.017
3. FTND			–	.050	−.062	−.077
4. Average $RPE_{(Walk\ Test)}$				–	.057	.122
5. Average $HR_{(Walk\ Test)}$					–	−.020
6. Treadmill $speed_{(Walk\ Test)}$						–
Mean/n	109	14.4	5.4	12.3	110.7	2.8
SD/ %	69.4%	13.85	2.01	1.73	13.43	0.51

Gender (coded 0 = male, 1 = female); ASI-3 = Anxiety Sensitivity Index-3; FTND = Fagerström Test for Nicotine Dependence; RPE = Borg Rating of Perceived Exertion (average rating during walk test); HR = heart rate (average in bpm during walk test); Treadmill speed (self-selected for walk test). * $p < .05$; ** $p < .01$

Table 2 Predictors of RPE and HR during Rockport 1.0 mile treadmill walk test

Variable	Perceived exertion (RPE)				Heart rate (HR)			
	b	*se*	*z*	*p*	*b*	*se*	*z*	*p*
Linear time	0.041	0.081	0.50	.616	**1.415**	**0.247**	**5.72**	**<.0001**
Quadratic time	**−0.104**	**0.027**	**−3.90**	**<.0001**	–	–	–	–
Cubic time	**0.078**	**0.021**	**3.63**	**<.0001**	–	–	–	–
AS status	0.327	0.328	1.00	.319	−2.396	1.964	−1.22	.222
Linear time × AS	**0.411**	**0.143**	**2.88**	**.004**	−0.181	0.432	−0.42	.675
Quadratic time × AS	−0.014	0.045	−0.31	.753	–	–	–	–
Cubic time × AS	**−0.094**	**0.037**	**−2.56**	**.011**	–	–	–	–
FTND	0.025	0.066	0.38	.703	−0.429	0.442	−0.97	.332
Gender	0.158	0.288	0.55	.582	**4.729**	**1.950**	**2.43**	**.015**
HR (pre test)	–	–	–	–	**0.540**	**0.063**	**8.61**	**<.0001**

Significant effects are presented in bold

Table 2 for complete model results. Visual inspection of the raw RPE data suggested that a cubic effect of time was most appropriate for the model, and this was statistically significant (see Fig. 1, top). In addition, there was a significant cubic time × anxiety sensitivity interaction ($b = -0.094$, $SE = 0.037$, $z = -2.56$, $p = .011$), but not a main effect of anxiety sensitivity. The form of the interaction indicated that both groups show an increase in RPE at the beginning of the walk test, but that low anxiety sensitivity group showed less increase after the initial increase. The effects of tobacco dependence and participant sex were not significant.

With regard to HR during the exercise test, visual inspection of the HR data suggested that a linear effect of time was most appropriate for the model, and this was statistically significant (see Fig. 1, bottom). The main effect of anxiety sensitivity and the linear time × anxiety sensitivity status interaction effect were not significant. There was a significant main effect of the pre-walk test HR and participant sex (see Table 2).

Discussion

The current study examined the effect of anxiety sensitivity on RPE and HR during a moderate-intensity submaximal exercise test among a sample of low-active treatment-seeking daily smokers. Findings indicated that on average, RPE levels during the walk test were 12.3 ($SD = 1.73$), which is within the range for moderate-intensity physical activity (American College of Sports Medicine, 2010). A significant interaction between RPE and time emerged. Specifically, for smokers with elevated levels of anxiety sensitivity (ASI-3 $\geq$ 17), the pattern of RPE reflected a stable persistent increase in effort throughout the walk test, with stabilized ratings towards the last 5 min. In contrast, smokers with lower levels of anxiety sensitivity (ASI $<$ 17) reported an initial early increase in RPE, which appeared to stabilize after about 5 min and was sustained throughout the duration of the trial, followed by a slight increase in the last 5 min of the walk test. Based on the form of the significant interaction, it could be inferred that

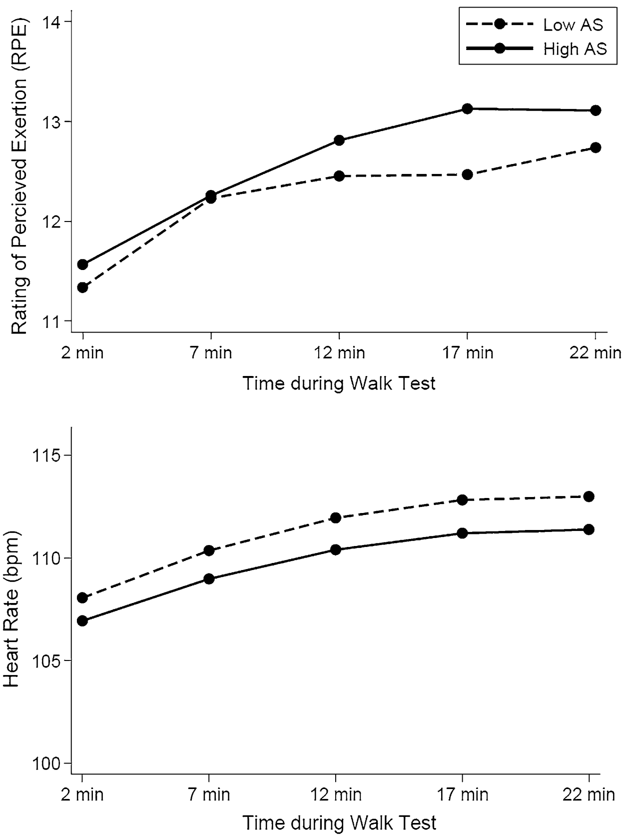

Fig. 1 Effect of elevated anxiety sensitivity on RPE and HR during walk test

anxiety sensitivity's influence on RPE may present only when exercise bout length and subsequent exertion are *prolonged*. Notably, when ratings during the walk test were averaged, we did not see a significant association between anxiety sensitivity and RPE. Thus, averaging these data appears to obscure important relationships between these variables and such variability appears to offer rich information about the changing momentary subjective experience of exercise during a bout of exercise for smokers with elevated anxiety sensitivity.

Changes in the elevated anxiety sensitivity group reflected an approximately 2 point increase in RPE from initiation of the exercise test, which roughly corresponds to the perception that HR increased by roughly 20 beats/min (Borg, 1998) and qualitatively, corresponds to a change in exertion levels from "light" to "somewhat hard" which could reflect increased breathlessness and fatigue during exercise. These changes are meaningful especially given a differential pattern of HR by anxiety sensitivity during the exercise test was not similarly observed. Taken together, anxiety sensitivity does not appear to influence observed HR during the bout of moderate-intensity exercise, however does "amplify" the subjective experience of exertion. The current results extend existing prior findings that examined the link between anxiety sensitivity and lower levels of cardiorespiratory fitness in a separate sample of sedentary treatment-seeking smokers (Farris et al., 2016), and parallel findings non-specific to smokers that indicate anxiety sensitivity predicts increased negative affect (i.e., fear) during exercise, particularly among individuals with higher body mass index (Smits et al., 2010). Of note, RPE is a *subjective* rating of exertion and effort, including breathlessness and fatigue during exercise, and while is distinct from the affective response to exercise, they may certainly influence one another (Baldwin et al., 2016).

Several additional findings warrant discussion. The submaximal exercise testing protocol used in the current study instructed smokers to "choose the fastest speed they could walk" for one mile, and this speed was set for the entire test (i.e., speed was fixed within-participant). In this sample of smokers, self-selected speed on the treadmill was not significantly associated with anxiety sensitivity, although all participants were encouraged to choose a speed that ensured their target HR was within the range for moderate-intensity exercise. Thus, it is unknown how anxiety sensitivity may influence a smoker's tendency to self-select a lower-intensity form of exercise if given the opportunity to do so. It is also unknown how anxiety sensitivity may influence a smoker's likelihood of discontinuing moderate-intensity exercise if given the opportunity to do so. Additionally, the current study, and one prior (Farris et al., 2016), utilized submaximal exercise protocols that were discontinued based on pre-determined parameters (e.g., distance reached; peak oxygen uptake reached). Given smokers with elevated anxiety sensitivity (a) perceive greater exertion during prolonged bouts of exercise (as demonstrated in the current study), which may increase the experience negative affect during exercise, and (b) have lower cardiorespiratory fitness levels (Farris et al., 2016), these factors could result in early termination of bouts of exercise and/or decreased likelihood of future engagement in physical activity. This remains to be empirically examined.

In addition, like other studies, we did not to find an association between level of tobacco dependence and anxiety sensitivity (Leventhal & Zvolensky, 2015) and level of tobacco dependence was not associated with RPE or HR during the exercise test. Theoretically, the effects of smoking on respiratory and cardiovascular functioning might contribute to and/or potentiate the physically distressing experience of aerobic exercise, which could increase RPE during exercise. It is important to further consider the impact of smoking behavior on the subjective physiological and affective experience of aerobic exercise, as this might aid in further understanding barriers to exercise engagement in this particularly health-vulnerable sub-group of the population (Shaw & Agahi, 2014).

There are several study limitations. First, the acute bout of physical activity in this study was in the context of a laboratory setting where the participants were aware that the researchers were examining their cardiorespiratory fitness level. The perception of being evaluated could have influenced ratings of RPE. Second, the tendency to be aware of and negatively appraise interoceptive sensations is likely influenced by a host of individual difference factors (not limited to anxiety sensitivity), including genetic factors (Bryan et al., 2007) and body weight (Ekkekakis & Lind, 2006; Smits et al., 2010). While beyond the scope of the current investigation, future work could examine these and other individual differences factors that may influence the experience of exercise. Third, it is unknown how the patterning of RPE and HR would change during the course of more physically intensive aerobic exercise (e.g., vigorous-intensity exercise) or with alternative forms of aerobic exercise (e.g., running, cycling). Negative affect appears to increase during exercise when the intensity of exercise *exceeds* an individuals' ventilatory threshold (when ventilation starts to increase at a faster rate than maximum oxygen intake; (Ekkekakis, 2003, 2005; Ekkekakis et al., 2005), which if the resulting somatic sensations are apprised or interpreted as harmful or intolerable (Ekkekakis, 2005), will elicit negative arousal states (e.g., tension, distress; Ekkekakis et al., 2008). Thus, it is important to replicate and extend the current findings to alternative forms/intensities of aerobic exercise. Nevertheless, the current exercise test reflects a moderate-intensity bout of walking that could be conceptualized as more generalizable to bouts of physical activity that smokers actually achieve in their daily lives (e.g., brisk walking), therefore could have more ecological validity relative to other forms of exercise and intensities. Lastly, our sample lacked racial and ethnic heterogeneity, was primarily female, and was recruited on the basis of having elevated depressive symptoms, thus may not necessarily be generalizable to other low-active groups of smokers.

There is evidence that "prescribing" an affect-based exercise program to guide the intensity of activity (i.e., how one feels to determine intensity), versus a HR-based exercise-intensity prescription, results in greater uptake in moderate-to-vigorous intensity exercise, greater positive affective response to exercise, and higher average HR during exercise, particularly among individual with low level of cardiorespiratory fitness levels (Baldwin et al., 2016). Thus, it is possible that tailoring exercise prescription to maximize the affective response to bouts of physical activity for smokers with elevated anxiety sensitivity, who have lower cardiorespiratory fitness levels (Farris et al., 2016), could result in greater uptake in exercise. Additionally, the current data could suggest that multiple shorter, relative to longer, bouts of physical activity could be more sustainable for smokers with elevated anxiety sensitivity. Moreover, given anxiety sensitivity is targetable in cognitive-behavioral treatment (Smits et al., 2008), if addressed, can be used to promote smoking cessation and increased engagement in physical activity (Smits et al., 2015). By directly addressing anxiety sensitivity via cognitive-behavioral intervention and increasing the affective response to exercise, smokers with anxiety sensitivity may experience prolonged bouts of aerobic exercise as less physically effortful and more enjoyable, which can increase the likelihood that these individuals engage in physical activity that will have greater cardiovascular benefits (i.e., higher intensity; longer bouts).

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Compliance with ethical standards

Conflict of interest Samantha G. Farris, Lisa A. Uebelacker, Richard A. Brown, Lawrence H. Price, Julie Desaulniers, and Ana M. Abrantes declare that they do not have any conflict of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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