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Anxiety in patients referred for elective coronary angiography: a prospective cohort study

Anja Kokalj Palandacic[1,2*], Saša Ucman[1], Dragan Kovacic[3], Brigita Novak Sarotar[1,2†] and Mitja Lainscak[2,4†]

Abstract

Background Medical procedures have the potential to elicit feelings of anxiety, which have been associated with reduced health-related quality of life and cardiac dysfunction. The prevalence of anxiety in patients referred for elective coronary angiography (CA) ranges from 24% to 72%. Anxiety, in combination with coping, was rarely assessed apart from depression in these patients. The aims of this study were to determine the prevalence of anxiety, assess its correlation with coping traits, and with elective CA findings in non-depressed patients.

Methods This was a single-center, prospective cohort study. Anxiety was evaluated: two weeks before, on the day of CA, 24-hours post CA, and one month post CA. Psychological parameters were determined using self-administered questionnaires and anxiety was analyzed on those without depressive symptoms. The association between anxiety and psychological variables was assessed by multiple linear regression and by linear mixed effect model.

Results Out of 393 patients screened for depression and anxiety, 259 non-depressed patients (age 65 years, 36% women) were analyzed. Anxiety was present in 91/259 (35%) of patients. Avoidance-oriented coping was a significant predictor of higher trait anxiety ($p < 0.001$) and lower state anxiety 24-hours post CA. CA indicated no intervention in 183 patients (71%), while revascularization, either percutaneous (49 patients, 19%) or surgical (27 patients, 10%), was performed in the remaining patients. Anxiety decreased between the baseline and all subsequent time points ($p < 0.001$) in all groups.

Conclusions More than one third of non-depressed patients experience clinically significant anxiety before CA. Avoidance-oriented coping has a significant impact on anxiety. The findings of our study suggest the routine screening for anxiety and coping strategies prior to elective CA might be helpful to identify those individuals who are in need for additional psychological interventions.

Clinical trial number The study was registered at ClinicalTrials.gov (NCT02804009).

Keywords Anxiety, Coronary angiography, Avoidance-oriented coping, Percutaneous coronary intervention, Coronary artery bypass graft surgery

†Brigita Novak Sarotar and Mitja Lainscak contributed equally as joint last authors to this work.

*Correspondence:
Anja Kokalj Palandacic
anja.kokalj@psih-klinika.si
[1]University Psychiatric Clinic Ljubljana, Chengdujska 45, Ljubljana 1000, Slovenia
[2]Faculty of Medicine, University of Ljubljana, Vrazov trg 2, Ljubljana 1000, Slovenia
[3]Department of Cardiology, General Hospital Celje, Oblakova ul. 5, Celje 3000, Slovenia
[4]Division of Cardiology, General Hospital Murska Sobota, Ul. dr. Vrbnjaka 1, Murska Sobota 9000, Slovenia

Introduction

Elective coronary angiography is a gold standard to detect and treat coronary artery disease (CAD). Medical complications, such as low blood pressure, rhythm disturbances, perforation of the coronary vessels are rarely seen [1]. Any medical procedure, particularly invasive, can have an impact on an individual's thoughts, feelings, and behaviors, potentially leading to increased anxiety or depression [2]. Anxiety can manifest through psychological and physical symptoms. Frequent psychological symptoms are tension and worry. Specific physical symptoms of anxiety include symptoms of vegetative arousal (dry mouth, palpitations, sweating, trembling), symptoms in the chest and abdomen (feeling of heavy breathing, suffocation, chest pain, nausea), and general physical symptoms (tingling, restlessness, muscle tension, inability to relax, difficulty swallowing) [3]. Anxiety can be a source of distress and is associated with poor prognosis, impaired health-related quality of life, and can cause cardiac dysfunction such as arrhythmias [4, 5]. The prevalence of anxiety disorders or anxiety alone in patients undergoing coronary angiography has been previously investigated in cardiology and psychosomatic medicine, with scarce information and estimated prevalences ranging from 24% to 72% [4, 6, 7]. Additionally, angina – the cardinal CAD symptom – has also been associated with a higher prevalence of anxiety [8–10]. Consequently, it is an important factor to consider in cardiology treatment and rehabilitation.

Anxiety can be a relatively stable personality trait, indicating a tendency to respond with anxiety under stressful circumstances, referred to as trait anxiety. This trait contributes to variations in the frequency, intensity, and duration of episodes of state anxiety (defined as anxiety as a state at a given point in time) and negative affect [11, 12]. When examining anxiety, coping strategies play a role in this context. Coping strategies are defined as changing cognitive and behavioral efforts that are used to modify psychological and physiological responses and consequently, influence quality of life, health-related behaviors, and well-being after an acute cardiac event [13–16]. Coping has been categorized as problem-oriented, emotion-oriented, and avoidance-oriented [17]. In cardiology research, emotion-oriented strategies at the time of the cardiac event are a reliable predictor of disease severity at three-month follow-up [15]. Avoidance-oriented coping strategies are frequently used by anxious or depressed patients, whereas turning to religion and having greater social support are known to reduce anxiety in patients after myocardial infarction [14, 18]. Although anxiety and depression are the most studied psychological symptoms in patients referred for coronary angiography, only a limited number of studies have extended the rationale towards coping strategies that may predict anxiety in these patients. The understanding of these associations may be used in brief personalized psychological interventions for lowering anxiety.

Approximately 50% of patients with CAD suffer from depression and anxiety [19, 20]. The latter is important due to their well-established correlation. The most recent theoretical perspective, the cognitive behavioral model, proposes that reactivity leads to anxiety, which then progresses to depression through avoidance [21]. In individuals with anxiety disorders, anxious mood frequently overlaps with depressed mood in everyday experience [21, 22]. A 2015 meta-analysis of 44 studies demonstrated the significance of controlling for depressive symptoms, indicating that anxiety was associated with poor cardiac outcomes. However, upon adjustment for depression, the association became non-significant [23]. Comorbid anxiety and depression or depression alone have more adverse outcomes and poorer recovery and treatment outcomes [24, 25], hence this study focused on anxiety trajectories around coronary angiography in patients without clinically significant depression.

We designed this prospective cohort study with the following objectives: first, to determine the prevalence of trait anxiety in patients without depression before elective coronary angiography; second, to examine the associations of trait anxiety with coping strategies; and third, to assess whether changes in state anxiety differ across patient subgroups according to coronary angiography findings.

Methods

Study design, population, recruitment, data collection

This was a single-center, prospective cohort study. Consecutive patients referred for elective CA were recruited at the Coronary Care Unit of the Department of Cardiology at General Hospital Celje, Slovenia, between October 2015 and March 2017. The study protocol was approved by two separate ethics committees: the National Ethics Committee of Slovenia (No. 0120–344/2015-4 KME 62/12/15) and the Ethics Committee of Celje General Hospital (No. 22/2015-5). The study was also registered at ClinicalTrials.gov (NCT02804009). All study procedures were conducted only after obtaining written informed consent.

The protocol has been previously described elsewhere [26]. In brief, the inclusion criteria were referral for coronary angiography due to suspected CAD, heart failure etiology, unexplained arrhythmia, or cardiomyopathy etiology, as well as completed first set of questionnaires two weeks prior to the procedure. Patients were excluded if they had diagnostic coronary angiography prior to valve replacement surgery, were unable to independently complete the questionnaires or provide written consent, had undergone another coronary angiography within the last

six months, or had a diagnosis of concurrent mental illness. Patients with depressive symptoms, as determined by the Slovenian version of the Cardiac Depression Scale (S-CDS), were excluded due to known interrelation between depression and anxiety. Anxiety was assessed: two weeks before coronary angiography, two hours prior to the procedure, 24 h after the procedure, and one-month post-procedure. Psychological parameters were assessed using self-administered questionnaires. The outcome measures and follow-up points are summarized in Fig. 1. Patient characteristics were retrieved from medical records. Patients included in the study were referred for coronary angiography based on physical diagnoses suggesting suspected CAD, heart failure, arrhythmia or cardiomyopathy. No psychiatric diagnoses were assessed, apart from exclusion of patients with clinically significant depression symptoms. To analyze the course of state anxiety across groups with different procedure outcomes, patients were categorized into three groups: no indication for revascularization, percutaneous revascularization, and referral for surgical revascularization.

Psychological instruments

Following instruments were used:

(1) Spielberger Trait/State Anxiety Inventory (STAIT, STAIS) is a two-dimensional self-assessment questionnaire measuring the level of current anxiety symptoms (state anxiety) and general anxiety proneness (trait

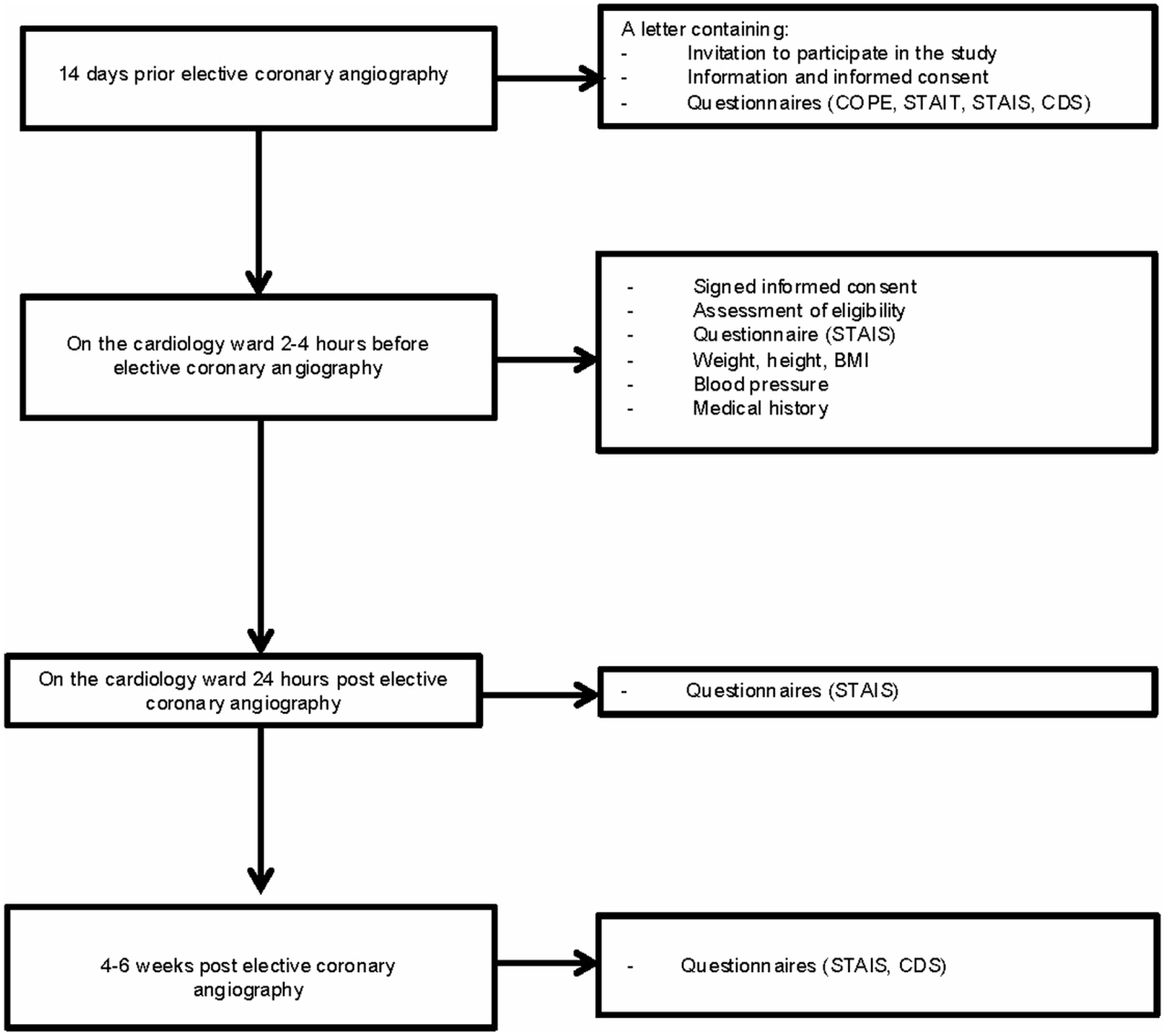


Fig. 1 The flowchart of the outcome measures and follow-up points. Anxiety was assessed: two weeks before elective coronary angiography (CA), two hours prior to CA, 24 h post CA, and one month after CA. Psychological parameters were assessed using self-administered questionnaires (COPE = The Coping Inventory, STAIT = The Spielberger Trait Anxiety Inventory, STAIS = The Spielberger State Anxiety Inventory, CDS = The Cardiac Depression Scale, BMI = body mass index)

anxiety). Responses for the STAIS scale assess intensity of current feelings "at this moment" on 1–4 scale, from 1- "not at all" through 2- "somewhat", 3- "moderately so" to 4- "very much so". For the STAIT the main question is "how you generally feel" and the response indicates frequency from 1- "almost never", 2- "sometimes", 3- "often" and 4- "almost always". Scoring should be reversed (1 = 4, 2 = 3, 3 = 2, 4 = 1) for 19 out of 40 items. The final/total score for each dimension is the sum of all associated items. The sum of all items on each scale is 20–80; a higher score indicates greater anxiety. A cut-off value representing the presence of clinically significant symptoms was proposed at 40. The original validation study reported Cronbach's alpha between 0.86 and 0.95, indicating high internal consistency [12, 26]. The STAI was translated into Slovenian language by Lamovec in 1988 [27]. The Cronbach's alpha in this study was 0.92 for trait anxiety and 0.95 for the state anxiety inventory.

(2) The Coping Inventory (COPE) measures the individual's unique responses to stressful events. It measures active coping, planning, suppression of competing activities, restraint coping, seeking of instrumental social support, seeking of emotional social support, positive reinterpretation, acceptance, humor, turning to religion, focus on or venting of emotions, denial, substance use, behavioral disengagement and mental disengagement. Each item is scaled from 1- "I usually don't do this at all", 2- "I usually do this a little bit" through 3- "I usually do this a medium amount" to 4- "I usually do this a lot". The total score is a sum of its items [28]. The COPE inventory has established subscales; however, these were originally developed and validated in non-clinical populations [28]. In the context of cardiac setting, the patterns of inter-item correlations and the clustering of coping behaviours may differ. In addition, given the large number of items in the inventory, an exploratory factor analysis was conducted to create higher-order factors, as suggested by Carver [29]. Principal axis extraction with varimax rotation was used and retained factors based on eigenvalues > 1. Items with loadings below 0.4 were excluded. Three factors were extracted (see Supplemental Table 1). The reliability coefficients (Cronbach's alpha) were 0.92 for active coping, 0.84 for social-emotional coping and 0.74 for avoidance-oriented coping, confirming the instrument's good internal reliability. The resulting factor structure was stable and replicable across rotation methods, supporting the validity of these second-order factors in our sample.

(3) The Cardiac Depression Scale (CDS) is used to measure depression in patients with heart disease. It has seven reliable and distinct components that include Mood, Anhedonia, Cognition, Uncertainty, Sleep, Inactivity, and Hopelessness. Twenty-six items on the CDS are scored on a 7-point Likert-type scale ranging from 1- "strongly disagree" to 7- "strongly agree". Items 2, 4, 12, 15, 19, 20, 23 are reverse scored (1 = 7, 2 = 6, 3 = 5, 4 = 4, 5 = 3, 6 = 2, 7 = 1). Higher scores on the CDS indicate more severe depression. The total CDS score is the sum of all items and ranges from 26 to 182 [30]. The estimated internal consistency in the original study was 0.9 and the critical score of 95 has been determined to have a sensitivity of 97% and a specificity of 85% for depression, as determined by the Mini International Neuropsychiatric Interview [30, 31]. The CDS was translated into Slovenian language, and its psychometric values were determined. The Cronbach's alpha in our study was 0.95 [31, 32]. The cut-off point of 95 or higher was used to detect clinically significant depressive symptoms.

Statistical analysis

The sample size was determined based on the results of previous studies and the design of this study, which has been previously described [26]. In summary, we estimated a sample size of 350 patients, with proposed sample sizes for three groups according to elective coronary angiography findings. Numerical variables are reported as mean ± standard deviation (SD), while categorical variables are reported as number (%). Independent samples t-test or chi-squared test was used to compare differences between trait anxiety groups. To reduce false discovery rate, Benjamini-Hochberg correction was used to adjust p-values. The psychometric properties of the measures were assessed using Cronbach's alpha coefficient of internal consistency. Exploratory factor analysis using principal axis extraction and varimax rotation was conducted to verify the COPE inventory. The mean scores of active coping, social-emotional coping, and avoidance-oriented coping were used as independent variables in a linear regression analysis. The association between baseline trait anxiety and psychological variables was assessed by multiple linear regression with the trait anxiety designated as the dependent variable. The analysis was adjusted for age, sex, and risk factors for CAD (body mass index, smoking, hypertension, hyperlipidemia, diabetes mellitus, angina pectoris, family history of coronary artery disease). A linear mixed-effects model was used to assess differences in state anxiety, with a subject as a random effect and time and coronary angiography finding as fixed effects. The analysis was also adjusted for age, sex, and risk factors for CAD. Complete case analysis was used in multiple linear regression model; meanwhile missing data were handled using linear mixed-effects model for repeated measures to account for partially missing follow-up data under the assumption of missing at random. Statistical analyses were performed using the R statistical package version 4.3.2 (R Foundation for Statistical Computing, Vienna,

Austria), and IBM SPSS Statistical Package for Social Science, version 23.0. (IBM, Armonk, New York).

Results

Study population

A total of 858 consecutive patients were invited to participate in the study and were considered for enrollment. Following the application of the inclusion and exclusion criteria, 259 patients who did not exhibit symptoms of depression were eligible for evaluation of trait anxiety. Of these, 253 had complete data at baseline and were included in the assessment of secondary outcomes. Out of 253 patients, 243 patients filled out questionnaires the day after elective coronary angiography and 191 patients filled out questionnaires one-month post-procedure (Fig. 2).

Table 1 presents patient characteristics according to trait anxiety, along with demographic, psychosocial, CAD risk factors, and coronary angiography findings. Among the 393 patients, 134 (34%) exhibited clinically significant depressive symptoms. After exclusion, the mean age of the 259 patients without clinical depression was 65 years, and 32% were female. Of these, 121 (47%) had CAD, 48 (19%) had heart failure and 63 (24%) had arrhythmias. In the anxious group ($n = 91$), 44 (48%) had CAD, 12 (13%) had heart failure and 21 (23%) had arrhythmias. No statistically significant differences were observed between the groups with or without anxiety after application of the Benjamini-Hochberg correction (Table 1).

Trait anxiety outcomes

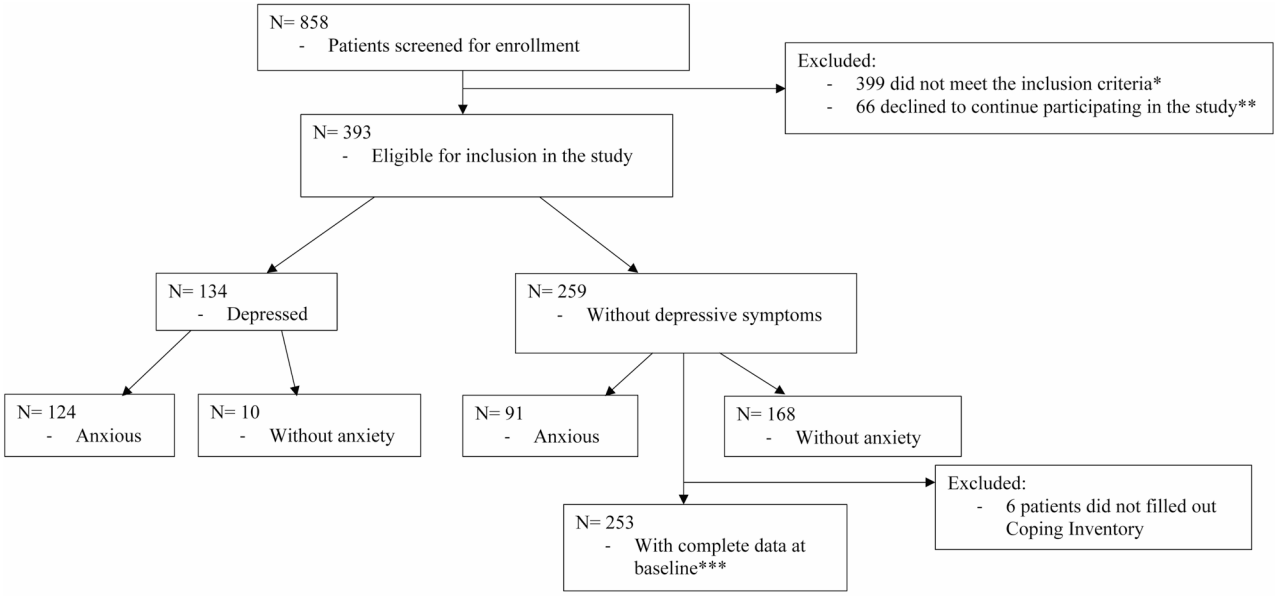
The mean trait anxiety score was 38.4 ± 7.5; among the 259 patients, 91 (35%) exhibited clinically significant trait anxiety. After applying the inclusion and exclusion criteria, 253 patients (98%) were eligible for the statistical analysis. Six patients were excluded due to incomplete Coping Inventory data (Fig. 2). Table 2 presents the cardiac diagnoses and coronary angiography findings for 253 patients included in the statistical analysis of trait and state anxiety.

The findings revealed a positive association between trait anxiety and avoidance-oriented coping strategies ($\beta = 0.41$, 95% CI [0.29, 0.53], $p < 0.001$), as illustrated in Fig. 3.

State anxiety outcomes

No between-group differences in state anxiety were found; however, a significant time-related decrease was observed in all groups (Fig. 4; Table 3).

The linear mixed-effects model demonstrated a statistically significant decrease in state anxiety between the baseline and subsequent time points ($p < 0.001$; Table 3).



*Reasons for not meeting the inclusion criteria were: diagnostic ECA before valve replacement surgery (n=135); CA in the last 6 months (n=37); unable to independently fill out the questionnaires (n=58); physical/mental disease (n=42); unable to provide written consent (n=8); incomplete first set of questionnaires (N=119).
**17 patients declined participation on-site before ECA; 26 patients declined participation 24 hours after ECA; 23 patients declined participation on follow up.
*** 253 patients filled out questionnaires on the day of ECA, 243 patients filled out questionnaires the day after ECA, 191 patients filled out questionnaires 4 weeks after ECA.

Fig. 2 The study flowchart illustrates the number of consecutive patients who met the enrollment criteria. It is noteworthy that 34% of the subjects who met the eligibility criteria were diagnosed with depression. (CA = coronary angiography, ECA = elective coronary angiography)

Table 1 Clinical and demographic characteristics by anxiety status (patients without depressive symptoms)

Characteristic	All (*n* = 259)	Without Anxiety (*n* = 168)	Anxious (*n* = 91)	*p*-value*
Age, mean (SD)	64.6 ± 8.9	64.3 ± 8.9	65.2 ± 8.8	0.944
Female, n (%)	82 (32)	53 (32)	29 (32)	1.000
BMI ≥ 30 kg/m^2, n (%)	101 (39)	68 (41)	33 (36)	0.664
Smoking, n (%)	47 (18)	28 (17)	19 (21)	0.944
Known CAD, n (%)	121 (47)	77 (46)	44 (48)	0.950
Hypertension, n (%)	237 (92)	150 (89)	87 (96)	0.410
Hyperlipidemia, n (%)	196 (76)	122 (73)	74 (81)	0.510
Diabetes mellitus type 2, n (%)	78 (30)	50 (30)	28 (31)	0.999
Angina pectoris, n (%)	171 (66)	102 (61)	69 (76)	0.410
Dyspnea, n (%)	112 (43)	71 (42)	41 (45)	0.950
Family history of CAD, n (%)	90 (35)	57 (34)	33 (36)	0.950
Number of CA, n (%)				0.950
First	202 (78)	132 (79)	70 (77)	
Two or more	57 (22)	36 (21)	21 (23)	
CA approach, n (%)				1.000
Femoral	225 (87)	146 (87)	79 (87)	
Radial	34 (13)	22 (13)	12 (13)	
CA finding, n (%)				0.410
No revascularization	183 (71)	116 (69)	67 (74)	
PCI performed	49 (19)	38 (23)	11 (12)	
CABG scheduled	27 (10)	14 (8)	13 (14)	
Waiting time, n (%)				0.919
3–6 months	149 (58)	93 (55)	56 (62)	
1–3 months	110 (42)	75 (45)	35 (38)	

SD Standard deviation, *BMI* Body mass index, *CA* Coronary angiography, *CABG* Coronary artery bypass graft surgery, *CAD* Coronary artery disease, *PCI* Percutaneous coronary intervention

*Benjamini-Hochberg correction

Table 2 Cardiac diagnoses and coronary angiography findings of 253 patients included in the statistical analysis of trait and state anxiety

Medical diagnosis	No revascularisation	PCI	CABG
Coronary artery disease, n (%)	43 (28%)	47 (94%)	25 (92%)
Arrhythmias, n (%)	49 (32%)	9 (18%)	5 (10%)
Heart failure, n (%)	37 (24%)	5 (10%)	6 (10%)

CABG Coronary artery bypass graft surgery, *PCI* Percutaneous coronary intervention

Additionally, a statistically significant interaction between avoidance-oriented coping strategies and time indicates that the relationship between avoidance and state anxiety changes over time. The use of avoidance-oriented coping strategies was associated with reduced state anxiety 24 hours after the procedure in comparison with the baseline (β = -0.22, 95% CI [-0.35, -0.10], $p < 0.001$). The effect was found to be weaker on the day of the procedure ($p = 0.039$) and became non-significant a month after the procedure ($p = 0.477$).

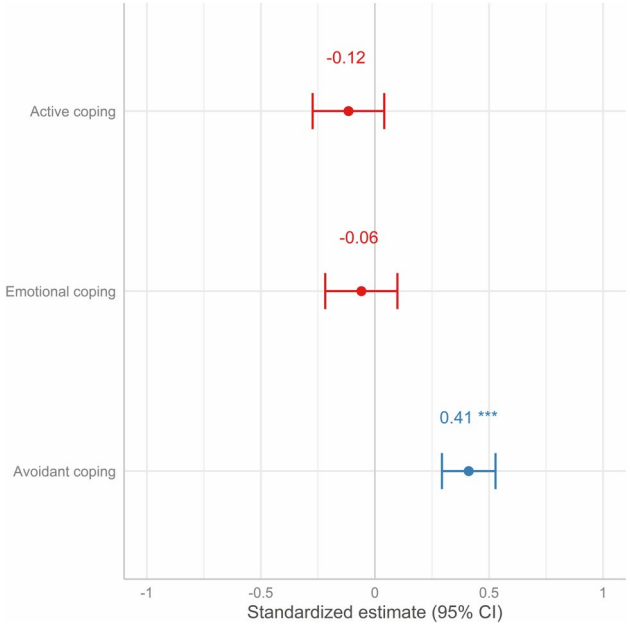


Fig. 3 Association between coping strategies and anxiety (n = 253). The graph displays the standardized estimate of the regression coefficients, with a 95% confidence interval. Avoidance-oriented coping strategies were a significant predictor of higher anxiety. The analysis was adjusted for age, sex, and risk factors for coronary artery disease (body mass index, smoking, hypertension, hyperlipidemia, diabetes mellitus, angina pectoris, family history of coronary artery disease). ***p < 0.001, **p < 0.01, *p < 0.05

Discussion

The present study extends the current knowledge towards better understanding of psychological parameters about trait and state anxiety in non-depressed patients referred for elective coronary angiography. Main findings are as follows: firstly, 35% of non-depressed patients referred for elective coronary angiography exhibited clinically significant anxiety; secondly, the use of avoidance-oriented coping strategies was found to be associated with higher trait anxiety; thirdly, state anxiety decreased in all three groups (no indication for revascularisation, percutaneous revascularisation, and referral for surgical revascularisation) and in all three subsequent time points in relation to the baseline; fourthly, the use of avoidance-oriented coping strategies was associated with lower state anxiety on the day of and 24-hours post coronary angiography.

Trait anxiety and coping strategies

Depression and anxiety symptoms frequently overlap, and controlling for depressive symptoms is important. This assertion is supported by the meta-analysis by Celano et al., which demonstrated that anxiety alone was not associated with cardiac mortality [23]. After controlling for depressive symptoms we demonstrated that more

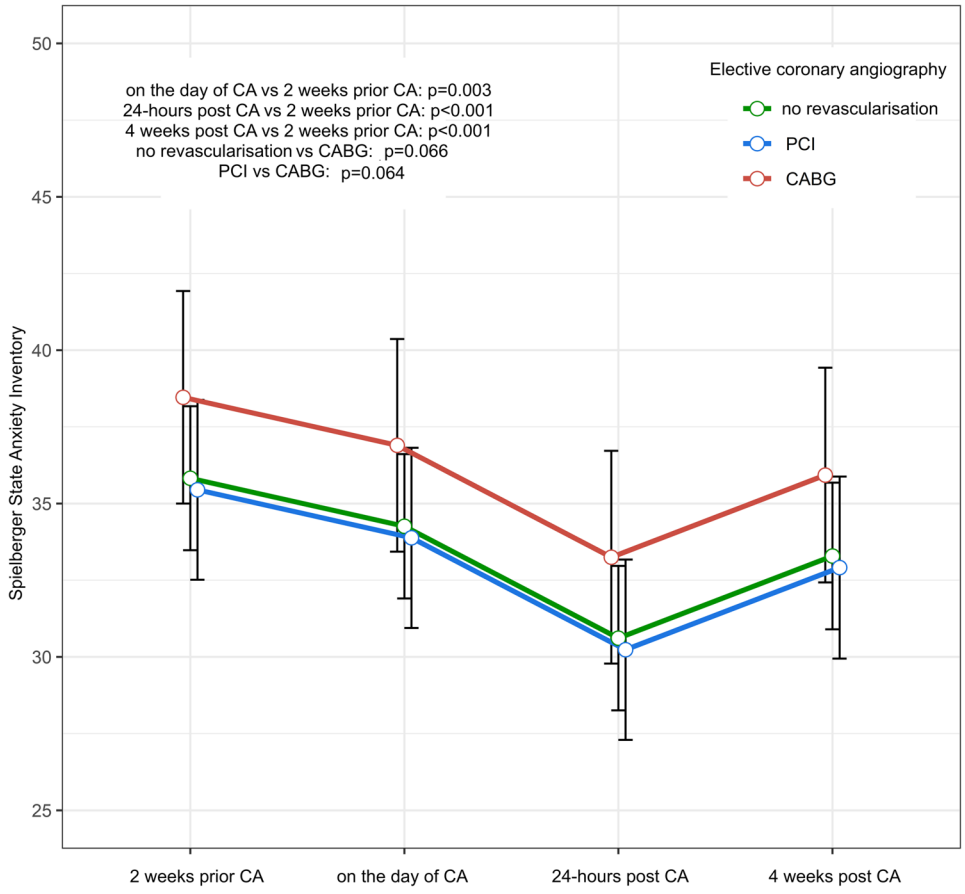


Fig. 4 An estimate of average state anxiety scores (with 95% confidence interval) according to elective CA finding and over time (adjusted according to linear mixed effect model). (CABG = coronary artery bypass graft surgery. CA = coronary angiography. PCI = percutaneous coronary intervention)

than 35% of patients experienced clinically significant anxiety. The prevalence of anxiety in our sample is higher than that observed in the general population and aligns with the findings of previous studies in patients undergoing angiography [4, 7, 33–35]. Surprisingly, none of the traditional risk factors, such as hypertension, hyperlipidemia and diabetes mellitus type 2 were associated with anxiety.

The present study confirmed that avoidance-oriented coping strategies were positively associated with trait and state anxiety, even after adjusting for other variables. Avoidance-oriented strategies are defined as maladaptive coping responses, given their function in distancing individuals from their stressors. This is exemplified by the use of denial and maladaptive behaviors, such as alcohol and substance use [36]. Furthermore, in cases where individuals exhibit higher trait anxiety, avoidance has been observed to positively correlate with various anxiety disorders, including agoraphobia, specific phobias, and social anxiety disorder [11, 36–38].

State anxiety and CA findings

In accordance with prior research, anxiety varied over time [4, 35, 39]. State anxiety was higher at the baseline (2 weeks prior coronary angiography) than on the day of the procedure (hospital admission), presumably due to concerns about the disease and potential underlying conditions [40]. On the day of hospital admission, 2–4 hours prior the procedure, anxiety levels decreased. Research suggests that pre-procedural anxiety may decline following initial contact with the medical staff. Reassurance regarding the routine nature of the procedure and low chance of complications, reduces the potential of procedure related fears [41]. Anxiety reached its lowest levels 24 hours after the procedure. The observed decline could be attributable to the standardized pre-procedural administration of 5 mg oral diazepam, received by all patients. With a half-life of approximately 72 hours, which is longer than the interval we used to assess the post-procedural anxiety, diazepam could have contributed to the reduction in anxiety beyond the immediate postprocedural period [42, 43]. In addition, previous research suggests that pre-procedural anxiety is associated with uncertainty regarding coronary angiography

Table 3 Associations and interactions between time points, coping strategies, clinical characteristics and state anxiety

Predictor	Estimate (B)	Standardized Beta	95% CI for B	95% CI for β	*p*-value
(Intercept)	32.26	0.16	20.98 to 43.53	-0.36 to 0.68	< 0.001
Time [t2]	**-3.42**	**-0.18**	**-9.35–2.50**	**-0.30 – -0.06**	**0.003**
Time [t3]	**-4.52**	**-0.60**	**-10.49–1.45**	**-0.71 – -0.48**	**< 0.001**
Time [t4]	**-5.79**	**-0.29**	**-12.10–0.52**	**-0.42 – -0.16**	**< 0.001**
CA approach [diagnostic]	-2.69	-0.31	-5.57–0.18	-0.63–0.02	0.066
CA approach [PCI]	-3.06	-0.35	-6.31–0.18	-0.72–0.02	0.064
Waiting time [1–3 months]	-1.40	-0.16	-3.10–0.31	-0.35–0.03	0.107
CA approach [radial]	-1.16	-0.13	-3.61–1.29	-0.41–0.15	0.353
Number of CA	-0.10	-0.01	-2.17–1.97	-0.25–0.22	0.926
Active coping	-2.42	-0.17	-4.82 – -0.02	-0.33 – -0.00	0.048
Emotional coping	0.06	0.00	-2.26 to 2.39	-0.13 to 0.14	0.957
Avoidance coping	8.01	0.36	5.26–10.76	0.23–0.48	**< 0.001**
time [t2] × active coping	1.61	0.11	-0.75–3.97	-0.05–0.27	0.180
time [t3] × active coping	1.02	0.07	-1.35–3.39	-0.09–0.23	0.400
time [t4] × active coping	-0.94	-0.07	-3.45–1.57	-0.24–0.11	0.461
time [t2] × emotional coping	0.85	0.05	-1.93–3.62	-0.11–0.21	0.550
time [t3] × emotional coping	1.82	0.10	-0.99–4.63	-0.06–0.27	0.203
time [t4] × emotional coping	3.19	0.18	0.09–6.29	0.01–0.36	0.043
time [t2] × avoidance coping	**-2.88**	**-0.13**	**-5.60 – -0.15**	**-0.25 – -0.01**	**0.039**
time [t3] × avoidance coping	**-5.02**	**-0.22**	**-7.84 – -2.21**	**-0.35 – -0.10**	**< 0.001**
time [t4] × avoidance coping	-1.12	-0.05	-4.20–1.96	-0.19–0.09	0.477

Legend: The analysis was adjusted for confounding variables, including age, sex, and risk factors for coronary artery disease such as body mass index, smoking, alcohol consumption, hypertension, hyperlipidemia, diabetes mellitus, angina pectoris, family history of coronary artery disease

CA Coronary angiography, *PCI* Percutaneous coronary intervention

results [44]. At 24 hours post-procedure, patients were informed about the outcome of the procedure and possible future interventions (e.g., referral for surgical revascularization). This resolution of uncertainty could have contributed to the observed decline in state anxiety. One-month after coronary angiography, state anxiety remained significantly lower than at baseline but was higher than on the day following the procedure. State anxiety reflects patients' feelings of anxiety in relation to the potentially stressful coronary angiography. By this point, the stressor had largely been resolved, and most patients had returned to normal functioning. These findings are consistent with previous research showing that anxiety decreases over time after the procedure [45, 46]. However, when the interactions between coping and time were added to the model, a negative association between avoidance-oriented coping and state anxiety was found. The use of avoidance-oriented coping strategies lowered state anxiety on the day of, and 24hours after, coronary angiography. At this two time points, avoidance-oriented strategies may serve as an adaptive coping response, when individuals perceive a situation as uncontrollable. Such strategies may be effective and offer a temporary relief while awaiting a medical procedure or when attempting to regain a sense of control afterwards – for example, when coping with the results of the procedure, or with any physical or emotional symptoms experienced during the procedure [37].

There was no difference in state anxiety level between coronary angiography groups, which contradicts previous research suggesting that patients with severe CAD are predisposed to anxiety and anxiety disorders [32, 35, 47–49]. This discrepancy may be attributed to the substantial variation in participant numbers across each coronary angiography group.

Clinical implications

Maladaptive coping, such as the use of avoidance-oriented strategies, is associated with higher anxiety. The physiological responses elicited by anxiety have the potential to influence the development of CAD [50]. The findings of our study suggest that routine screening for anxiety and coping strategies prior to elective coronary angiography may help identify individuals in need of additional interventions. Patients with clinically significant pre-procedural anxiety, but without marked distress, could benefit from brief psychological interventions, such as cognitive-behavioral therapy or psychoeducation [51, 52]. Recent studies have shown that virtual reality interventions assisting conscious sedation, can reduce periprocedural anxiety in cardiac patients [53]. Benzodiazepines are also effective in reducing preprocedural anxiety [43]; however, their use may be associated with adverse effects, such as hemodynamic instability, delirium, sleep disruption, and dementia [54–56]. In cases of severe emotional distress, the temporary use of these medications may be considered. Furthermore, patients undergoing coronary angiography with clinically significant anxiety and maladaptive coping strategies,

may benefit from an objective clinical evaluation of anxiety. If confirmed, evidence-based treatments such as cognitive-behavioral therapy and/or antidepressants, as recommended by NICE guidelines for generalized and panic disorder in adults, could be considered [57]. Cognitive-behavioral rehabilitation has been shown to reduce avoidance-oriented coping behavior and compared with classical cardiac rehabilitation, demonstrated larger effect sizes for avoidance behavior, somatization, anxiety and depression [58]. In patients with musculoskeletal disorders, cognitive-behavioral rehabilitation was further associated with higher work ability, improved physical functioning, reduced fear-avoidance beliefs, and lower pain at the 10-month follow-up [59].

Study limitations

The findings should be interpreted considering the potential limitations. First, they may not be representative due to potential sampling bias and moderate sample size. However, screening of all consecutive patients and comparability with studies alike, makes our research methodologically comparable to the literature. Second, the data collection period spanned approximately two years, and the calculated sample size was not attained. The collection of data revealed that not all state anxiety questionnaires were completed (Fig. 2). To maintain statistical power and utilize as much data as possible, the linear mixed effect model was employed in lieu of repeated measures ANOVA. The primary advantage of this model is its flexibility in the number of independent variables and its modern approach to longitudinal data analysis [60], and we believe it to be statistically adequate. Third, in our factor analysis of the COPE Inventory we used varimax rotation, which provided an interpretable three-factor solution. We also re-ran the factor analysis using an oblique rotation, which resulted in the same number of factors and a similar pattern of primary loadings, supporting the stability of the structure in our dataset. However, future studies should examine its replicability. Forth, the study was conducted from October 2015 and March 2017; however, due to COVID-19 pandemic and personnel changes, data analysis and manuscript preparation were delayed. While the core findings remain relevant, some clinical practices may have changed and should be considered when interpreting the results. Finally, we intentionally excluded patients with clinically significant depressive symptoms to isolate the effects of coping strategies on anxiety. However, by restricting the sample to non-depressed individuals, we may have conditioned on a collider (the absence of depressive symptoms), which can introduce collider stratification bias [61]. Collider bias occurs when two variables influence a third variable (the collider). Conditioning on the collider distorts the true associations between variables of interest [62]. Avoidance-oriented coping is associated with both anxiety and depression, and anxiety itself is a known risk factor for depression. Therefore, patients with high avoidance were likely to also be depressed [63]. By excluding individuals with depression, we may have removed the subgroup in which the association between avoidance-oriented coping and anxiety is the strongest, leading to an underestimation of the true effect. Similarly, this may also apply to other coping strategies and could partly explain the non-significant associations observed. While this methodological choice limits generalizability, it allowed us to focus specifically on anxiety trajectories in non-depressed patients undergoing coronary angiography.

Conclusions

Our study found that elevated trait anxiety was present in one-third of non-depressed patients referred for elective coronary angiography. State anxiety declined after the procedure in all vascularization groups, regardless of angiographic findings, suggesting that the completion of the procedure alleviates acute psychological distress. The transient rise in anxiety prior coronary angiography identifies a vulnerable period that may warrant targeted psychological and educational support. Furthermore, patients with higher trait anxiety frequently employed avoidance-oriented coping strategies, which may have unfavorable psychological outcomes. These findings highlight the importance of early recognition of anxiety and coping patterns in cardiac patients. Future longitudinal research is needed to clarify whether patients with elevated trait anxiety and avoidance-oriented coping undergoing coronary angiography reflect an underlying anxiety disorder; to examine the association between pre-procedural anxiety to adverse clinical outcomes, and to establish which subgroups of patients may benefit most from screening, psychological interventions, or pharmacological treatment.

Abbreviations

BMI	Body mass index
CA	Coronary angiography
CABG	Coronary artery bypass graft surgery
CAD	Coronary artery disease
CDS	The Cardiac Depression Scale
COPE	The Coping Inventory
S-CDS	The Slovenian version of the Cardiac Depression Scale
PCI	Percutaneous coronary intervention
STAIT	The Spielberger Trait Anxiety Inventory
STAIS	The Spielberger State Anxiety Inventory
SD	Standard deviation

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
A.K.P. – conceptualization, investigation, writing – original draft; S.U. – conceptualization, writing – review & editing; D. K. – investigation, writing – review & editing; B.N.S. - conceptualization, methodology, writing – review & editing, supervision; M. L. - conceptualization, methodology, writing – review & editing, supervision. All authors read and approved the final manuscript.

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Data availability
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study conformed to the principles of the Declaration of Helsinki. The study protocol was approved by two separate ethics committees: the National Ethics Committee of Slovenia (No. 0120–344/2015-4 KME 62/12/15) and the Ethics Committee of Celje General Hospital (No. 22/2015-5). The authors confirm that a signed patient consent form has been obtained for participation in the study. All study procedures were conducted only after obtaining written informed consent.

Consent for publication
Not applicable.

Competing interests
Mitja Lainscak and Brigita Novak Sarotar are funded by the Slovenian Research and Innovation Agency (Grant Nr. P3-0456). Anja Kokalj Palandacic, Sasa Ucman, Dragan Kovacic declare that they have no competing interests.

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