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ORIGINAL ARTICLE

On the protective effect of resilience in patients with acute coronary syndrome

Antonio L. Arrebola-Moreno, Rocío García-Retamero, Andrés Catena, Rafael Marfil-Álvarez, Rafael Melgares-Moreno, José A. Ramírez-Hernández

Hospital Universitario Virgen de las Nieves, Spain
Universidad de Granada, Spain
Center for Adaptive Behavior and Cognition, Max Plank Institute for Human Development, Germany

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Abstract Research on the contribution of positive personality traits to the progression of coronary heart disease (CHD) is notably absent. Resilience is the capacity to develop oneself successfully despite adverse circumstances. In a study of patients with acute coronary syndrome (ACS), the authors investigated the effect of resilience on indicators of CV severity and the physiological mechanisms underlying this effect. Patients (n=134) completed a scale measuring resilience. The authors measured troponin-I and myoglobin as indicators of ACS severity, and white blood cell (WBC) count and neutrophils as inflammatory markers. Results showed that self-efficacy-a component of resilience-was negatively related to both myoglobin and troponin after the acute coronary event. The relationship between resilience and these prognostic markers was mediated by the WBC count. Importantly, this result held significant after controlling for the effect of classic CV risk factors and demographics. The authors conclude that resilience decreases the extent of the myocardial infarction by affecting the inflammatory response, showing a protective effect.

Resumen En la actualidad la investigación sobre la influencia de los rasgos de personalidad positivos sobre la enfermedad coronaria (EC) es escasa. La resiliencia se define como la capacidad para autodesarrollarse con éxito a pesar de las circunstancias adversas. En un estudio, los autores han investigado el efecto de la resiliencia en varios indicadores de severidad en pacientes con síndrome coronario agudo (SCA; n=134) y los mecanismos que subyacen a este efecto. Los pacientes completaron una escala que median sus niveles de resiliencia. Los autores midieron los niveles de troponina-I y mioglobina como indicadores...
Cardiovascular disease (CVD) is a major public health burden in the industrialized countries, including the United States and Europe (World Health Organization [WHO], 2011). Most recent estimates from the American Heart Association suggest that one third of American adults (i.e., nearly 80 million people) have some form of CVD (Roger et al., 2012). The most common forms are: coronary heart disease (CHD), chest pain, heart failure, and stroke (Rogers et al., 2011). Data from prospective-cohort and case-control studies showed that modify the risk factors (e.g., smoking, high lipid levels, obesity, physical inactivity, low daily fruit and vegetable consumption, and alcohol overconsumption) are important predictors of risk of CVD (Yusuf et al., 2004).

There is also a growing body of literature showing that psychological factors play a crucial role in adverse cardiovascular outcomes (Pelle et al., 2009). To illustrate, methodologically sound epidemiological studies indicated that negative emotions, including stress, and sub-facets of negative affectivity (e.g., depression) contribute to the initiation and progression of CVD (Denollet et al., 2004). Data from prospective-cohort and case-control studies showed that modify risk factors (e.g., smoking, high lipid levels, obesity, physical inactivity, low daily fruit and vegetable consumption, and alcohol overconsumption) are important predictors of risk of CVD (Yusuf et al., 2004).

Resilience is related to the way individuals cope, overcome, and become positively strengthened by changes and challenges and has been largely studied in younger and older adults (Fry & Keyes, 2010). Resilient individuals use positive emotions to rebound from stressful experiences quickly and effectively (Giltay et al., 2006), and find positive meaning in negative circumstances.

Resilient individuals have also been found to build supportive social networks that facilitate coping, and to show a faster cardiovascular recovery after negative events (Tugade et al., 2004). For instance, Tugade and Fredrickson (2004) measured cardiovascular responding to a laboratory stressor in a sample of undergraduates. Six indices of cardiovascular responding were collected, including heart rate, finger pulse amplitude, pulse transmission times to the finger and the ear, and diastolic and systolic blood pressure. The authors calculated an aggregate index of duration of cardiovascular reactivity (time to return to baseline levels) for each participant by computing the mean duration score for each participant by computing the mean duration score across these six indices, and showed that participants with higher resilience evidenced faster cardiovascular recovery from negative emotional arousal. Similarly, Chan et al., and Wong (2006) showed that CHD patients with higher resilience achieve better health outcomes than low-resilient CHD patients in response to an 8-week rehabilitation program, as indicated by higher physical and mental measures, lower...
On the protective effect of resilience in patients with acute coronary syndrome

A number of pathophysiological mechanisms have been proposed to explain the relationship between psychological factors and cardiovascular outcomes, including hypothalamic-pituitary-adrenal axis dysregulation, platelet activation, and inflammation (Cohen et al., 2012). Circulating inflammatory markers are important predictors of cardiac risk, as they are often associated with increased incidence of adverse cardiac events (Sabatine et al., 2002) as well as increased mortality after controlling for conventional risk factors (Ikonomidis, Stamatelopoulos, Lekakis, Vamvakou, & Kremastinos, 2008). For instance, increases in interleukin (IL)-6, tumor necrosis factor alpha, and C-reactive protein play an important role in the pathogenesis and progression of CVD and are associated with various psychosocial factors including early life adversity, stress, hostility, and social isolation (Steptoe, Hamer, & Chida, 2007). The total white blood cell (WBC) count and the percentage of neutrophils are also predictors of cardiovascular outcomes (Cabrerizo-García, Zalba, Pérez, & Ruiz, 2010). In fact, a recent systematic review showed that the percentage of neutrophils measured during admission are related to mortality rate and/or to major adverse clinical events in patients with lower resilience. However, there is a dearth of research investigating the effect of resilience on indicators of CVD severity and the physiological mechanisms underlying this effect (Feder, Nestler, Westphal, & Charney, 2010).

In the current research, we investigated whether resilience influences cardiovascular prognosis in patients with ACS. In particular, we investigated whether resilience affects levels of troponin-I and myoglobin-two cardiac enzymes that are released to the vascular system after a myocardial infarction. These enzymes serve as sensitive and specific indicators of damage to the myocardium and tend to be reliable indicators of ACS severity in clinical practice (Thygesen et al., 2012). Peak levels of these enzymes after an acute coronary event correlate with the extension of the MI and provide important prognostic information (Heidenreich et al., 2001). We also investigated the physiological mechanisms underlying the effect of resilience on ACS severity. Following Feder et al. (2010), we examined whether this effect is mediated by inflammation (i.e., total WBC count and percentage of neutrophils). In our analyses we controlled for the effect of risk factors including age, sex, hypertension, diabetes, dyslipidemia, smoking, and body mass index (BMI).

**Method**

**Sample**

Our participants were 134 consecutive patients (average age of 61.8 years, SD=9.80, range 31-82; 82% males) who were admitted to the hospital “Virgen de las Nieves” of the University of Granada with ACS. Patients’ sociodemographic features are displayed in Tables 1 and 2. Half of the patients had dyslipidemia and ST elevation; one third smoked and had diabetes; and almost 60% had hypertension. Patients with or without ST-segment elevation were eligible to participate in the study. The inclusion criteria for participation were having elevated cardiac markers (i.e., Troponin-I) and having ischemia. The exclusion criterion were having an inflammatory disease and/or having neurological problems. Seventy-nine percent of the

| Table 1 Percentage of patients with classical risk factors and ST elevation. |
|---------------------------------------------|-----|-----|----------------|
| **Variable**                        | **No** | **Yes** | **Statistical test** |
| Smoking                             | 84   | 50   | $\chi^2=8.63, p<.01$ |
| Hypertension                        | 57   | 77   | $\chi^2=2.985, p>.08$ |
| Diabetes                            | 87   | 47   | $\chi^2=11.94, p<.01$ |
| Dyslipidemia                        | 64   | 70   | $\chi^2=2.7, p>.6$ |
| ST elevation                        | 67   | 67   | $\chi^2=0.0, p=1.00$ |

* A ST-segment elevation myocardial infarction (STEMI) usually reflect an acute coronary occlusion and indicates a poor early-term clinical outcome, whereas a non-STEMI (NSTEMI) usually reflect a critically ill but not complete coronary artery obstruction and indicates a poor long-term clinical outcome (Park et al., 2013).

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| Table 2 Averages, 95% confidence intervals (CI), standard error of the mean (SEM), and median of resilience factors and biochemical markers. |
|---------------------------------------------|-----|-----|-----|-----|-----|-----|
| **Factor** | **Average** | **95% CI LL** | **95% CI UL** | **SEM** | **Median** |
| Age       | 61.80        | 60.12        | 63.47        | 0.85    | 63.00    |
| BMI       | 28.77        | 28.01        | 29.53        | 0.38    | 28.03    |
| Troponin I| 31.49        | 25.10        | 37.89        | 3.23    | 13.94    |
| Myoglobin | 496.29       | 370.18       | 622.41       | 63.76   | 200.35   |
| WBF       | 10.23        | 9.59         | 10.87        | 0.32    | 9.39     |
| Neutrophils| 69.86       | 67.80        | 71.92        | 1.04    | 70.70    |
| RS self-efficacy | 59.21 | 57.31        | 61.11        | 0.96    | 62.00    |
| RS purpose | 31.14        | 30.12        | 32.17        | 0.52    | 31.50    |
| RS Cognitive Avoidance | 39.15 | 38.01        | 40.29        | 0.58    | 40.50    |
approached patients were eligible and agreed to participate in the study. Patients were recruited prospectively between July 2011 and December 2011 at bedside 3 days after the ACS. Patients were recruited by a trained assistant, who described the purpose of the study and answered questions. We followed the guidelines of the European Society of Cardiology for diagnosis (see ESC Guidelines, 2007) to recruit participants. The Ethics Committee of the Hospital “Virgen de las Nieves” of the University of Granada approved the methodology of the study. All participants signed an informed consent form to participate in the study.

Instruments and procedure
Participants’ demographics, anthropometric, and laboratory data— including fasting lipid profile and serum glucose—were measured at baseline. We measured age, sex, height, and weight in all participants. All participants provided a medical history and underwent a clinical examination. Standardized questionnaires were used to determine participants’ medical history, medication use, and their cardiovascular risk. Participants were classified as hypertensive if they (a) had an average systolic blood pressure of >140 mm Hg and/or a diastolic blood pressure of >90 mm Hg at rest, (b) had previous history of hypertension, or (c) were taking antihypertensive drugs. Patients were classified as diabetics if they (a) had fasting blood glucose of >126 mg/dL, (b) had previous history of diabetes mellitus, or (c) were taking insulin/oral hypoglycemics. A fasting venous sample was collected in all patients, and total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglyceride levels were determined by standard enzymatic methods.

Resilience. Participants completed the Wagnild and Young (1993) Resilience Scale (RS), which is a 25 item Likert-type rating scale that measures degree of resilience. It includes a number of protective health factors such as self-esteem, flexibility, ability to deal with conflict, availability of external support, and familiar cohesion. The scale was translated into Spanish by skilled translators. The translated version showed very good psychometrics (Cronbach’s alpha = .90). Previous research identified two (Heilemann, Lee, & Kury, 2003; Wagnild & Young, 1993) or three components (Rodriguez et al., 2009) in exploratory factor analyses. We conducted an exploratory factor analysis with principal components extraction and Varimax rotation. With result ts consistent with previous research, we identified the following three components in this analysis (KMO=0.76, Bartlett sphericity test p<.001): self-efficacy, or the ability to cope with difficult and complex situations as well as the strength to do it (Cronbach’s alpha=.86; 11 items, examples of items are “I usually manage one way or another,” and “I am able to depend on myself more than anyone else”); purpose, or the ability to stay motivated over time and be operative (Cronbach’s alpha=.75; 6 items, examples of items are “When I make plans, I follow through with them,” and “I am determined”); and meaning of life and cognitive avoidance, or the ability to find positive aspects in life events, and to avoid dealing with situations when you cannot change them (Cronbach’s alpha=.73; 7 items, examples of items are “I feel proud that I have accomplished things in life,” and “I do not dwell on things that I can’t do anything about”). One item (“I seldom wonder what the point of it all is”) did no load in any of the three factors.

After completing this scale, participants answered other unrelated questions. These results will be reported elsewhere. Participants completed the questionnaires at bedside while they stated at the Hospital “Virgen de las Nieves.” There were no time constraints, but the questionnaire took approximately 30 min to complete.

Biochemical markers. We measured the following markers:

1. Indicators of ACS severity. Venous samples were collected in all patients at admission, and 3, 6, and 12 h. after admission. We used standard enzymatic methods to measure peak levels of cardiac damage enzymes after the coronary event (i.e., troponin-I and myoglobin).
2. Inflammatory markers. Venous samples were collected in all patients at admission and leucocytes (i.e., total WBC count) and percentage of neutrophils were measured using standard methods.

Statistical analyses
Demographics and characteristics of the sample of participants were analyzed using descriptive statistics and χ² statistical tests (Table 1; see Montero & León, 2007; Ramos-Alvarez, Moreno-Fernández, Valdés-Conroy, & Catena, 2008). Biochemical markers and resilience were positively skewed (Table 2). Therefore, we computed non-parametric Spearman rho correlations.

Troponin-I, WBC count, neutrophils, and components of resilience were converted into binary variables using their corresponding medians as cut points. BMI was dichotomized by using the standard value of 25. We defined two clusters of variables: predictor variables (the three components of resilience, i.e., RS self-efficacy; RS purpose; and SRRS) and control variables (ST elevation; classical risk factors including age, sex, hypertension, diabetes, dyslipidemia, smoking, and BMI; and inflammatory markers including WBC count and neutrophils).

We conducted logistic regression analyses to test whether predictor and control variables predict severity of ACS severity (i.e., levels of troponin-I and myoglobin) (Model I). Significant predictor and control variables were then submitted to a hierarchical logistic multiple regression analysis to determine whether significant components of resilience improve the prediction of severity of ACS after including significant control variables in the equation (Model II). Odds ratios were computed to evaluate the effect size of the variables. Chi-square test and Nagelkerke R² were computed to evaluate improvements in predictive power when components of resilience were added to Model II. The Hosmer-Lemeshow test was used as the goodness-of-fit test of regression models.

To investigate whether the relationship between resilience and severity of ACS is mediated by inflammatory markers, we conducted mediational analyses following Preacher and Hayes (2008), with components of resilience as predictors, indicators of ACS severity as the criterion variables, and the significant inflammatory markers (i.e.,
WBF and neutrophils) as mediators. Indirect effects were tested by using an accelerated and bias corrected bootstrap procedure (5000 samples), implemented in the Preacher and Hayes' PROCESS macro. Variables were mean centered, and heteroscedasticity standard errors were used. In the analyses, we controlled for the effect of ECG ST deviation and classical risk factors by including these variables as covariates. Inflammatory markers were also included as moderators in the analyses to test whether they modulate (rather than mediate) the effect of components of resilience on severity of ACS. All the statistical decisions were conducted using a two-sided .05 significance level.

**Results**

**Resilience, severity of acute coronary syndrome, and inflammatory markers**

Table 3 shows the relationships between components of resilience, inflammatory markers, and indicators of ACS severity. RS self-efficacy is related to severity of ACS (troponin-I, r= −.21, p=.02, and myoglobin, r= −.17, p=.05) and WBC count (r= −.19, p=.03). In contrast, RS purpose and cognitive avoidance are not related to ACS severity or inflammatory markers. In addition, RS purpose is related to age (r=.23, p=.01) and hypertension (r=.21, p=.02). In addition, most of the classical risk factors were related to troponin-I (age, r= −.22, p=.01, diabetes, r= −.23, p=.01, smoking habits, r= −.19, p=.03), myoglobin (age, r= −.20, p=.02, sex, r= −.24, p=.01, diabetes, r= −.18, p=.04), and WBC count (age, r= −.25, p=.003, sex, r= −.23, p=.01). Finally, ST elevation was associated to troponin-I (r=.61, p=.001), myoglobin (r=.58, p=.001), WBC count (r=.27, p=.001), and neutrophils (r=.25, p=.004).

Logistic regression on troponin-I (Model I) indicated that ST elevation and classical risk factors accounted for a significant amount of variability (block $\chi^2(1,122)=57.37$, $p<.001$, Nagelkerke $R^2=.46$, HL $\chi^2(8)=3.35$, $p=.91$). Only ST elevation (reference category: STEMI, OR=7.29, $p<.001$, sex (reference category: female, OR=4.33, $p=.03$), and WBC count (reference category: low counts, OR=4.08, $p=.01$) were significant. The predictive power of Model II was also significant (block $\chi^2(8)=7.01$, $p=.01$, Nagelkerke $R^2=.51$, HL $\chi^2(8)=12.69$, $p=.12$). RS self-efficacy significantly improved prediction power (reference category: High self-efficacy, OR=3.55, $p=.01$), indicating that patients with low RS self-efficacy tended to have higher levels of myoglobin than those with high RS self-efficacy.

**Mechanism explaining the relationship between resilience and severity of acute coronary syndrome**

When WBC count was included as a mediator in the regression analysis, the relationship between RS self-efficacy and troponin-I remained significant ($c'$ path= −1.72, $p=.017$; see Figure 1). The relationship between RS self-efficacy and WBC count (a) and between WBC count and troponin-I (b) was also significant ($a$= −.36, $p=.04$, $b=2.28$, $p<.001$). Both the total (estimate= −2.53, $p=.001$) and indirect effects (Bootstrap estimated effect: −.80 95% CI [−1.81, −.12]) of RS self-efficacy on troponin-I were significant. In addition, our analysis showed that WBC count act as a mediator rather than as a moderator of the relationship between RS self-efficacy and troponin-I, $F_{(1,122)}=6.89$, $p=.41$.

Finally, when WBC count was included as a mediator in the regression analysis, the relationship between RS self-efficacy and myoglobin was not significant ($c'$ path= −.29, $p=.52$; see Figure 2). In contrast, the relationship between RS self-efficacy and leukocytes (a) and between leukocytes and troponin-I (b) were significant ($a$= −.35, $p=.038$, $b=1.42$, $p<.001$). The total (estimate= −.79, $p=.04$) and indirect effects of RS self-efficacy on myoglobin (Bootstrap estimated effect: −.50 95% CI [−1.07, −.08]) were significant. Again, our analysis showed that WBC count acts as a mediator rather than as a moderator of the relationship between RS self-efficacy and myoglobin, $F_{(1,122)}=.74$, $p=.39$.

**Discussion**

In this study, we aimed at investigating the influence of resilience on biological parameters of inflammation and severity in the acute setting of an ACS. Results showed that
self-efficacy—a component of resilience—was negatively related to peak levels of both troponin and myoglobine after an acute coronary event. Both myoglobine and troponin are important cardiac enzymes that are released after necrosis of the myocardium in the context of an acute coronary event. They are considered as prognostic markers as they reflect the magnitude of necrosis. Our results further showed that the relationship between self-efficacy and these prognostic markers was partially mediated by WBC count (i.e., an inflammatory marker). Importantly, this result held significant after controlling for the effect of ST elevation, patients’ age, sex, body mass index, smoking habits, HTA, diabetes, and dyslipidemia. Thus, self-efficacy might influence the size of the myocardial infarction by affecting the inflammatory response, showing a protective effect.

Published research converges to suggest that there is a direct relationship between inflammation and coronary atherosclerosis both in acute and chronic settings (He, Tang, Ling, Chen, & Chen, 2010). Previous research (e.g., Cabrerizo-Garcia et al., 2010; Dragu et al., 2008) also indicated that WBC count and percentage of neutrophils at admission are related to cardiovascular prognosis after an acute coronary event. In addition, Duvis et al., (2012) showed that depression predicts subsequent inflammation (e.g., leukocytes) in patients with stable CHD. In contrast, baseline levels of WBC count do not predict subsequent depressive symptoms, suggesting that depression is a risk-factor for inflammation which, in turn, predicts CHD. With our study, we add to this body of literature showing that the protective effect of resilience on CHD is also mediated by inflammation. In alignment with previous research, we assume that resilience might reduce inflammation rather than the other way around. This conclusion is supported by the fact that resilience is a personality trait relatively stable across long time periods (Bonanno, 2004; Seery, 2011; Wagnild, 2009). Therefore, it might not be influenced by transient levels of inflammation.

Our results are also consistent with research by Ikeda et al. (2011), who indicated that optimism, another positive
personality trait, also has a protective effect for CHD by reducing inflammation. In particular, the authors showed that higher overall optimism scores were associated to lower levels of interleukin-6—a cytokine with an important role in the inflammatory acute phase response. The study by Ikeda et al. (2011), however, was conducted in older men, free of CHD. Our research therefore is the first indicating that a positive personality trait tends to reduce inflammation in the context of an ACS and in turn influence the prognosis of CHD.

The potential mechanism by which psychological factors affect WBC count is not completely understood. Duivis et al., (2011) indicated that unhealthy behaviors explained the relation between depressive symptoms and the subsequent increase in the level of inflammatory cytokines in patients with stable CHD. However, these authors also showed that the relationship between depressive symptoms and levels of leukocytes were not related to levels of cytokines, BMI, waist-hip ratio, physical activity, or smoking. Therefore, the practice of health-damaging behaviors might not explain why self-efficacy influences WBC count. Other plausible explanations of this effect is the influence of chronic stress (Widmaier, Raff, & Strang, 2011), the sleep disturbance and poor sleep quality (Duivis et al., 2012), or the induction of hypercortisolism or reduced vagal activity (Gidron, Kupper, Kwaijtaal, Winter, & Denollet, 2007). As resilience is the capacity to overcome adverse events and to be able to develop oneself successfully despite very adverse circumstances, the most plausible explanation might be that resilience reduces (i.e., has a “buffering” effect against) the negative effects of stress.

Limitations of the study

We investigated whether resilience is a protective psychological factor in CHD. The extent to what other potential protective factors (e.g., hardness; Beasley, Thompson, & Davidson, 2003) have similar effects should be investigated in future research (Hartley, 2012). Participants in our study were a small sample of patients with ACS. Future research can also investigate whether our results hold in larger samples of healthy individuals and in patients with stable coronary heart disease. In addition, we used leukocytes (i.e., WBC count) and neurophils as an inflammatory marker. We did not investigate whether our results hold consistently in different subtypes of white blood cells (Widmaier et al., 2011; i.e. CD4 or CD8 T-cells). Future research should also investigate if some of these cell types fully mediate the relationship between resilience and severity in the acute setting of an ACS. Finally, we used a cross-sectional design in our study. Although our study can provide important theoretical insights, future search can investigate if our results hold consistently in a study using a longitudinal design.

Conclusions

Our research demonstrates that resilience decreases the size of the myocardial infarction in patients with ACS by affecting the inflammatory response. Thus, inflammation is a plausible mechanism affecting the influence that this psychological factor has on the prognosis after an acute coronary event. We hope that our study encourages future research investigating whether psychological therapy at early stages of CVD increases resilience in patients at high risk.

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