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ORIGINAL ARTICLE

Artificial FLOwering plants in Reducing Anxiety and depressive symptoms following Acute Coronary Syndromes (A-FLORA-ACS): a randomised controlled trial

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Abstract

Patients often experience emotional distress after acute coronary syndrome (ACS). These may lead to symptoms of depression or anxiety and greater morbidity/mortality. We sought to determine whether flowering plants in the coronary care ward reduced depressive and anxiety symptoms in these patients. Patients with ACS were randomly allocated to flowering plants (intervention) or no plants (control) in their room during index hospitalisation. Baseline data were collected. The primary outcome was the Hospital Anxiety and Depression Scale (HADS) depressive and anxiety symptom scores at discharge. Secondary outcomes were HADS depression and anxiety scores at 3 months. Both modified intention-to-treat (mITT) and per-protocol (PP) analysis were performed. 122 patients were included in the analysis after case exclusion, with all completing the HADS questionnaire at discharge and 89/122 (73%) patients completing the 3-month post-discharge HADS. At discharge, mean depressive symptom scores were lower in the intervention group, but only significantly so in the PP analysis (mITT 3.6/21 vs 4.6/21, $p=0.11$; PP 3.5/21 vs 4.9/21, $p=0.04$). There were no significant changes in between-group anxiety symptom scores (mITT 6.4/21 vs 6.1/21, $p=0.51$; PP 3.3/21 vs 3.6/21, $p=0.67$). The mean increase in depressive symptom scores at 3 months was smaller in the intervention group in both analyses (mITT 0.6 ± 3.6 vs 2.2 ± 2.6, $p=0.02$; PP 0.8 ± 3.6 vs 2.4 ± 2.7, $p=0.03$). Mean increase in anxiety symptom scores was not significantly different between groups (mITT 2.8/21 vs 2.5/21, $p=0.86$; PP 3.3/21 vs 3.6/21, $p=0.67$). Flowering plants during index hospitalisation for ACS reduced depressive symptoms in a per-protocol analysis but did not have a significant impact on anxiety symptoms. Increases in depression symptom scores were significantly smaller at 3 months post exposure to flowers compared to anxiety symptom scores.

Keywords Anxiety · Acute coronary syndrome · Depression · Flowers

Abbreviations

ACS	Acute coronary syndrome
CABG	Coronary artery bypass grafting
DALY	Disability-adjusted life years
GAD	Generalised anxiety disorder
HADS	Hospital Anxiety and Depression Scale
IQR	Interquartile range
NSTEMI	Non-ST-elevation myocardial infarction
PCI	Percutaneous coronary intervention
SD	Standard deviation
STAI-Y	Spielberger State Trait Anxiety Inventory Y
STEMI	ST-elevation myocardial infarction

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Introduction

Patients with acute coronary syndrome (ACS) may have high levels of anxiety and depression during and after their index hospitalisation [1–3]. Current literature suggests that the first 12 h after commencement of symptoms are associated with the highest level of anxiety [4]. It is common to experience intense emotional distress after an ACS, which could be associated with a variety of reasons including patient factors (underlying psychiatric illness), biological

factors (physiological response to a life-threatening illness) and situational factors [5].

Early distress typically resolves within the 3 months after the cardiac event, due to improvement of symptoms and physical capabilities [6, 7]. However, about one in five patients who experience a significant cardiac event [5], especially myocardial infarction [8], goes on to develop clinical depression which is associated with higher morbidity [9] and mortality [10, 11]. Generalised anxiety disorder (GAD) in the setting of established coronary artery disease is associated with higher rates of major adverse cardiac events than those without [12]. These psychiatric conditions play a prominent role in the morbidity of these patients and up to three percent of disability-adjusted life years (DALYs) in ischemic heart disease are attributable to major depressive disorder [13].

Flowering plants have been demonstrated to reduce patient anxiety, pain and a combination of both in non-cardiac ward settings such as surgery, radiology and day-procedure wards [14–19]. These benefits seem to extend further than just living plants, as images of flowering plants have demonstrated reductions in anxiety scores as well [20]. Considering this, we hypothesised that flowering plants can reduce depression and anxiety symptoms in post-ACS patients at discharge from a coronary care ward and at 3 months post discharge.

Methods

Patient selection

Patients with ACS (troponin positive type I myocardial infarction) were eligible for recruitment. Type I myocardial infarction was defined as the chest pain associated with a rise in cardiac biomarkers greater than the 99th percentile of the normal population with or without associated electrocardiogram changes. This was either an ST-elevation myocardial infarction (STEMI) or a non-STEMI (NSTEMI). Inclusion and exclusion criteria are highlighted in Supplementary Materials 1.

The trial was carried out at two coronary care units (Monash Medical Centre and Dandenong Hospital) in Melbourne from February 2016 to April 2017 (15 months including time to complete 3-month follow-ups). All patients were treated with maximum tolerated medical therapy including dual antiplatelet, high-dose statin therapy, beta-blockers and angiotensin-converting enzyme inhibitors, unless contraindicated. This research was approved by the Human Research Ethics Committee (HREC) of Monash Health, which also provided research oversight (approval number 16036L). As per the HREC of Monash Health, public trial registry was not required; the trial was registered in a local low-risk study database instead. The database included baseline demographics, cardiac risk factors, types of acute coronary syndrome, and questionnaire results. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Recruitment process

145 patients were approached for trial enrolment. 10 were excluded as they declined to participate; hence, 135 patients were recruited and randomised. 70 patients were initially in the intervention group and 65 were in the control group. However, 10 patients had crossed over from the control to intervention group (secondary to next of kin bringing in flowers), and 2 had crossed over from intervention to control group, making for 78 patients in the intervention group and 57 in the control group. We did not attempt to remove flowers brought in by next of kin as it might have caused unnecessary distress to patients. This is summarised in Fig. 1.

Once informed consent was gathered, patients were randomised to the intervention (receiving flowering plants) or control (without flowering plants) group within 48 h of their admission.

Randomisation process

Patients were assigned sequentially to numbers in a string of up to 140 produced using an online random number generator (https://www.randomizer.org) [21]. We generated 1 set of numbers from 1 to 140 in a random sequence using the drop-down boxes on the website. If the number assigned was even, patients received flowering plants. If it was odd, they received care as usual without the flowers. Once randomised, patients in the intervention group had the flowering plants located in their rooms and they accompanied the patients throughout their hospital stay if they moved rooms during their admission. Both groups had the same standard medical care. Due to the potential health risk of introducing live plants (allergen exposure, anaphylaxis and potentially infective soil micro-organisms), we used artificial flowering plants. We used four artificial potted roses for each patient (Fig. 2). Only one patient stated explicitly that they preferred real flowers to artificial ones but were still accepting artificial flowers in their room. No other patients requested for removal of the artificial flowers.

Data collection and Hospital Anxiety and Depression Score Questionnaire

Baseline data such as patient demographics, cardiac risk factors and previous anxiety or depression were collected. We

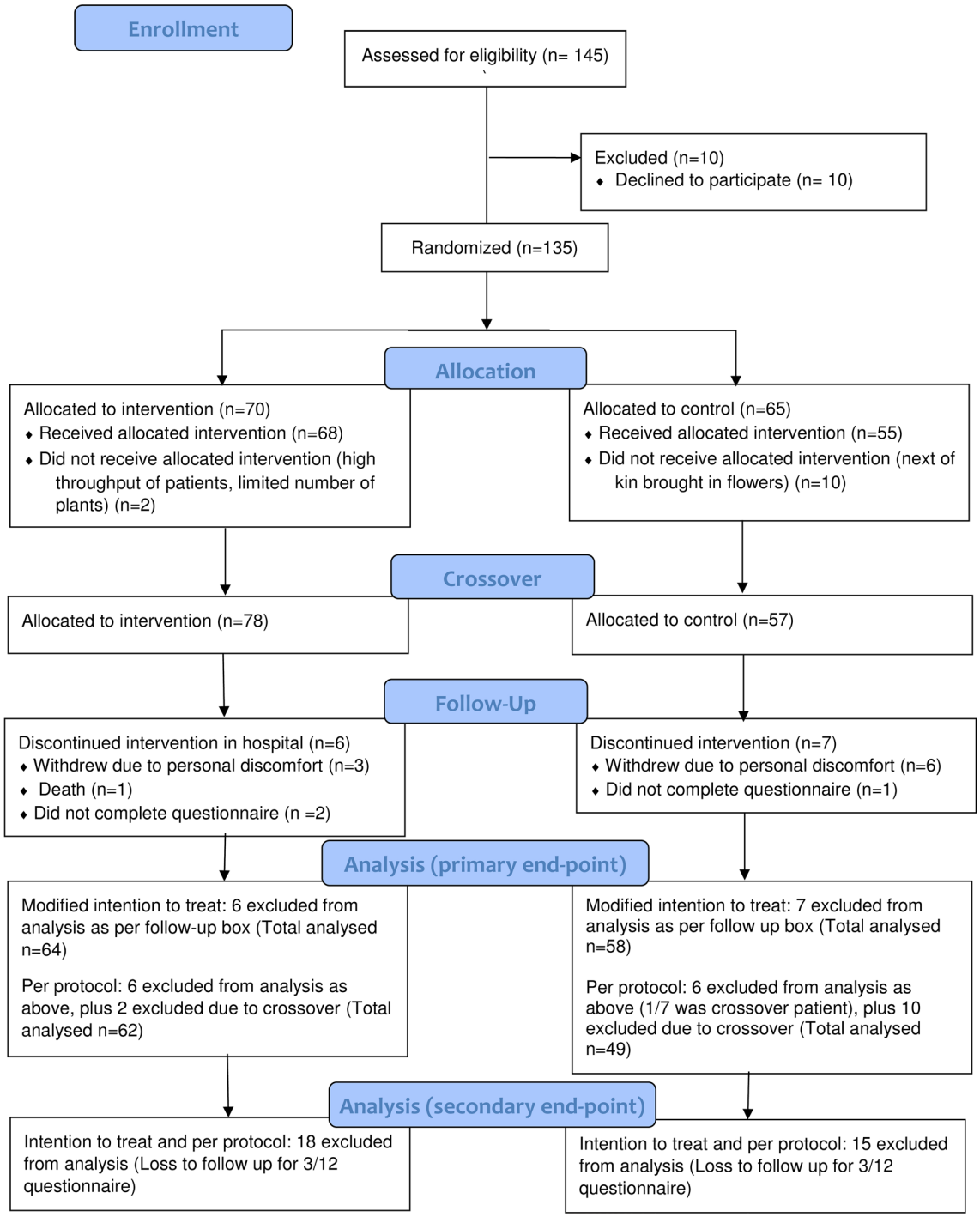

Fig. 1 Recruitment for A-FLORA-ACS

used the HADS (Hospital Anxiety and Depression Score), a 14-item questionnaire with two subsets of questions comprising depression and anxiety sections [22]. An example of the HADS questionnaire can be reviewed in the appendix (Supplementary Materials 2). Each section had seven questions and each question was graded with a score of 0–3 (higher scores indicating higher severity of symptoms). Questions were interspersed with one another with alternating score sequence (0–3 and 3–0). The HADS was easy for patients to self-administer and has been validated for use in populations with cardiovascular disease [23] with high internal consistency [24].

With a cut-off score of 8, the HADS has a sensitivity of 0.78 and a specificity of 0.9 as a positive screen for

Fig. 2 Artificial potted roses from IKEA—a combination of colours were used

depressive symptoms and a sensitivity of 0.79 and specificity of 0.83 as a positive screen for anxiety symptoms [25]. In patients with cardiovascular disease, where physical symptoms such as fatigue may bias results, scores of ≥ 4 for depression and ≥ 6 for anxiety have been used [26]. Aside from this, the HADS has been validated in non-hospital settings including general practice and the general community [25, 27], making it suitable for use as a follow-up tool post-discharge. Patients completed the first HADS questionnaire prior to discharge and the second HADS over the phone at 3 months post discharge.

Primary and secondary end points

The primary end-point for this trial was the sub-component HADS scores for depression and anxiety symptoms at discharge (total score of 21 points each). The secondary end-point was the same HADS sub-scores at 3 months. In addition, we examined the number of patients meeting the cut off HADs scores of ≥ 4 points for depressive symptoms and ≥ 6 points for anxiety symptoms, as well as the change between baseline and discharge scores between the intervention and control group.

Statistical analysis

Statistical analysis was performed with STATA, version 14.0. Statistical significance was defined as a level of significance of 5% on two-tailed tests. QQ plots demonstrated a positive skew to depression scores and normal distribution of anxiety scores. As our sample size in each group was reasonably large, parametric tests were appropriate. For both baseline data and results, parametric or non-parametric tests were used as appropriate. Two-tailed *t* tests were used to test for significance. The effect size (*r*) is given by calculating Cohen's *d*. As a rough guide, a value of 0.2 indicates a small effect, 0.5 a medium effect, and 0.8 a large effect.

Where appropriate, standard deviation (SD) was reported for mean and interquartile range (IQR) was reported for median values. For categorical data, Chi square test of independence or Fisher's exact tests were used as appropriate.

We performed both modified intention-to-treat (mITT) analysis and per-protocol (PP) analysis. mITT analysis is based on the initial treatment assignment and not on the final treatment received; it maintains randomisation and statistical power. mITT was chosen as there were several patients who withdrew or died before providing scores to discharge or 3-monthly questionnaires, which may have introduced more bias if missing scores were calculated by imputation.

In contrast, PP analysis refers to inclusion in the analysis of only those patients who adhered to the protocol. In our case, we excluded the crossover cases from the PP analysis, to estimate the true efficacy of the intervention as it was administered, at the expense of mild statistical power loss. Dual analysis was chosen due to ten cases of control-to-intervention crossover (e.g. visitors bringing in flowering plants to the patients), and two cases of intervention-to-control crossover (we had a fixed number of plants and when there were many patients in the unit, there were not enough to go around on two occasions). With power calculation, a minimum of 115 patients were required to achieve an effect size of 0.3. This calculation was based on calculating Cohen's *d* from four existing studies, all of which were randomised controlled trials evaluating the effect of plants, living or artificial, on symptoms of depression and anxiety [14, 16–18]. We have used the work of Thalheimer and Cook [28] and the programme G*power [29] for this purpose.

Results

Principal Findings

As per Fig. 1, 145 patients were assessed for eligibility and 135 were eventually randomised. There were 70 patients in the intervention group and 65 in the control group. After taking crossovers into account, 78 patients were in the intervention group and 57 were in the control group. However, for mITT analysis we used the pre-crossover numbers and for the PP analysis, we removed the crossover cases from our analysis.

Prior to completion of discharge questionnaire, six patients withdrew from the intervention group and six withdrew from the control group. 1 patient in the intervention group died. This left 122 patients for analysis, all of whom

completed the discharge questionnaire—64 in the intervention group and 58 in the control group.

The intervention group did not differ significantly from the control group in terms of baseline characteristics, except for more cardiac arrests in the intervention group at presentation (Table 1). Median flower exposure time was 3 days with interquartile range (IQR) of 3–5 days in the intervention group.

122 patients completed the HADS questionnaire at discharge. 2 patients, 1 from each group, died between completion of discharge and third-month questionnaire. 89 patients (73%) completed the 3-month post-discharge HADS questionnaire. 4 patients progressed to non-urgent inpatient coronary bypass artery grafting (CABG), 3 were managed with only medications post cardiac catheterisation, whilst the remaining 115 had percutaneous coronary stenting (Table 1).

Table 1 Baseline characteristics of participants, including traditional cardiac risk factors, type of myocardial infarction and type of cardiac intervention

	Intervention group ($n=64$, %)	Control group ($n=58$, %)	p value
Exposure days (median, IQR)	3.5 (3–5)		
Male gender	53 (82.8%)	52 (89.7%)	0.52
Previous depression	7 (10.9%)	9 (15.5%)	0.69
Previous anxiety	3 (5.1%)	5 (8.6%)	0.53
Cardiac arrest	8 (12.5%)	1 (1.7%)	0.02
Infarct type			
Anterior/lateral STEMI	22 (34.4%)	21 (36.2%)	0.94
Inferior/posterior STEMI	21 (32.8%)	22 (37.9%)	0.65
NSTEMI	20 (31.3%)	15 (25.9%)	0.44
Cardiovascular risk factors			
Family history IHD	20 (31.3%)	18 (31.0%)	0.88
Hypertension	29 (45.3%)	31 (53.4%)	0.47
Dyslipidaemia	27 (42.2%)	27 (46.6%)	0.75
Smoking	37 (57.8%)	31 (53.4%)	0.49
Overweight/obesity	15 (23.4%)	12 (20.7%)	0.64
Previous vascular disease[a]	9 (14.1%)	8 (13.8%)	0.91
Chronic kidney disease	10 (15.6%)	4 (6.9%)	0.12
Type of cardiac intervention			
PCI	59 (92.2%)	56 (96.6%)	0.30
CABG	3 (4.7%)	1 (1.7%)	0.34
Medical management post left heart catheterization	2 (3.1%)	1 (1.7%)	0.62

CABG coronary artery bypass surgery, *IQR* Interquartile range, *IHD* ischaemic heart disease, *NSTEMI* non-ST elevation myocardial infarction, *PCI* percutaneous coronary intervention, *STEMI* ST elevation myocardial infarction

[a]Includes peripheral vascular disease, cardiovascular disease, cerebrovascular disease

Primary and secondary end points

Intention-to-treat analysis—discharge

The primary end-point of HADS depression symptom score at discharge was not statistically significant between the intervention and the control group (3.6/21 vs 4.6/21, $t=1.61$, $p=0.11$, Cohen's $d=0.29$) (Table 2). 17/122 (13.9%) of participants met the cut-off of score ≥ 8 for depressive symptoms, with a significantly higher proportion of depressive symptoms in the control group (6.3% intervention vs 22.4% control, $p=0.01$). The anxiety scores at discharge were similar between both groups (6.4/21 vs 6.1/21, $t=-0.66$, $p=0.51$, Cohen's $d=0.24$). 40/122 (22.4%) of participants met the criteria for symptoms of anxiety using a cut-off of ≥ 8, with higher proportion of anxiety symptoms in the intervention group (42.2% intervention vs 22.4% control, $p=0.02$).

Intention-to-treat analysis—3 months

At 3 months, there were a total of 89 participants available for analysis. The attrition rate was 27% overall (23.4% in intervention group and 31.0% in control group, $p=0.35$); however, this difference was not significant between groups.

Depression symptom scores were 3.1 ± 3.3 in the intervention group and 2.5 ± 3.1 in the control group ($t=-0.89$, $p=0.37$, Cohen's $d=0.19$). We found that the mean change in depression scores was 0.6 ± 3.6 for the intervention group with and range of -8 to 10. The corresponding change in the control group was 2.2 ± 2.6 with a range of -2 to 7. The difference between both groups was considered as statistically significant ($p=0.02$) with a medium effect size (Cohen's $d=0.49$). A total of 7/89 participants who returned the 3-month questionnaire (7.9%) still met the cut-off for depressive symptoms, with a slightly greater proportion from the intervention group (8.2% vs 7.5% control, $p=0.91$), although this was not a statistically significant difference (Table 2).

Three-month anxiety scores were 3.5 ± 3.1 in the intervention group and 3.4 ± 3.1 in the control group ($t=-0.17$, $p=0.86$, Cohen's $d=0.04$). The mean change was 2.8 ± 0.5 for the intervention group (range -9 to 9) and 2.5 ± 0.5 for the control group (range -2 to 10). This difference was not statistically significant and was small (Cohen's $d=0.08$). A total of 10/89 (11.2%) of participants met the cut-off for anxiety symptoms with 12.2% in the intervention group and 10% in control ($p=0.62$).

Per-protocol analysis—discharge

When PP analysis was carried out, the mean depressive symptom scores for the intervention group were $3.5/21 \pm 2.7$

Table 2 Modified intention-to-treat: discharge and 3-month HADS depression and anxiety scores, and proportion meeting cut-off for depressive and anxiety symptoms

	Mean ± standard deviation	*t* statistic	Degrees of freedom (*df*)	*p* value	Effect size (Cohen's *d*)
Discharge					
Depression score intervention	3.6/21 ± 2.7	1.61	120	0.11	0.29
Depression score control	4.6/21 ± 3.9				
Anxiety score intervention	6.4/21 ± 3.7	−0.66	120	0.51	0.24
Anxiety score control	6.0/21 ± 3.3				
Three months					
Depression score intervention	3.1/21 ± 3.3	−0.89	87	0.37	0.19
Depression score control	2.5/21 ± 3.1				
Anxiety score intervention	3.5/21 ± 3.1	−0.17	87	0.86	0.04
Anxiety score control	3.4/21 ± 3.1				
Change in scores between discharge and 3 months					
Depression					
Intervention	0.6 ± 3.6 (range −8 to 10)	2.29	87	0.02	0.49
Control	2.2 ± 2.6 (range −2 to 7)				
Anxiety					
Intervention	2.8 ± 0.5 (range −9 to 9)	−0.36	87	0.72	0.08
Control	2.5 ± 0.5 (range −2 to 10)				

No. of patients meeting cut-offs for symptoms

	Discharge	*p* value	Three months	*p* value
Depression (total)	17/122 (13.9%)		7/89 (7.9%)	
Intervention	4/64 (6.3%)	0.01	4/49 (8.2%)	0.91
Control	13/58 (22.4%)		3/40 (7.5%)	
Anxiety (total)	40/122 (32.8%)		10/89 (11.2%)	
Intervention	27/64 (42.2%)	0.02	6/49 (12.2%)	0.62
Control	13/58 (22.4%)		4/40 (10%)	

Attrition rate	No. of dropouts	*p* value
Total	33/122 (27.0%)	
Intervention	15/64 (23.4%)	0.35
Control	18/58 (31.0%)	

and 4.9/21 ± 4.1 for the control group, which was considered as statistically significant ($p = 0.04$) with a small–medium effect size (Cohen's $d = 0.41$). 16/111 (14.4%) of participants met the cut-off of score ≥ 8 for depressive symptoms, with proportionally more representation from the control group (6.6% intervention, 24% control, $p = 0.01$). Anxiety scores were similar between both groups (3.3/21 vs 3.6/21, $t = 0.43$, $p = 0.67$, Cohen's $d = 0.10$). 39/111 (35.1%) of participants met the criteria for symptoms of anxiety using a cut-off of ≥ 8 (41.0% intervention, 28% control, $p = 0.15$).

Per-protocol analysis—3 months

At 3 months, there were a total of 80 participants available for analysis. The attrition rate was 32% overall (27.9% intervention, 24.6% control, $p = 0.39$); however, this difference was not significant between groups.

Depression symptom scores were 2.8 ± 3.0 for the intervention group and 2.8 ± 3.4 for the control group ($t = 0.11$, $p = 0.91$, Cohen's $d = 0.02$). The mean change in depressive symptom scores was 0.8 ± 3.6 (range −8 to 10) for the intervention group. The corresponding change in the control group was 2.4 ± 2.7 with a range of −2 to 7. Both ranges were similar to the mITT analysis. The difference between both groups was considered statistically significant ($p = 0.03$) with a medium effect size (Cohen's $d = 0.50$). A total of 6/80 participants who returned the 3-month questionnaire (7.5%) still met the cut-off for depressive symptoms (6.5% from intervention group and 8.8% from control group, $p = 0.70$).

Anxiety symptom scores were 3.3 ± 3.1 for the intervention group and 3.6 ± 3.2 for the control group ($t = 0.43$,

$p = 0.67$, Cohen's $d = 0.10$). The mean change was 2.8 ± 3.0 for the intervention group (range −9 to 9) and 2.8 ± 3.6 for the control group (range −4 to 10). This difference was not statistically significant and was small (Cohen's $d = 0.08$). A total of 6/80 (7.5%) of participants met the cut-off for anxiety symptoms (10.9% of intervention group, 11.8% control group, $p = 0.90$) (Table 3).

Discussion

Findings in context to current literature

The main difference between our mITT and PP analysis was a small improvement in depression scores in the intervention group that was statistically significant in the PP analysis. This is encouraging, and the reasons for this are explored below; however, this result must be interpreted carefully because the PP analysis excludes 12 cases of control-intervention crossover. In comparison, mITT analysis showed no difference in all HADS metrics used to assess the prevalence of anxiety and depressive symptoms.

In the mITT analysis, mean depressive symptom scores at discharge were higher in the control group and mean anxiety symptom scores at discharge were higher in the intervention group. In the PP analysis, mean depressive symptom scores were significantly higher in the control group but significantly so, and mean anxiety symptom scores were only slightly higher in the control group.

Both mITT and PP analyses show approximately 14% and 35% prevalence of depressive and anxiety symptoms, respectively, in our cohort. In both analyses, proportionally

Table 3 Per-protocol: discharge and 3-month HADS depression and anxiety scores, and proportion meeting cut-off for depressive and anxiety symptoms

	Mean ± standard deviation	*t* statistic	Degrees of freedom (*df*)	*p* value	Effect size (Cohen's *d*)
Discharge					
Depression score intervention	3.5/21 ± 2.7	2.13	109	0.04	0.41
Depression score control	4.9/21 ± 4.1				
Anxiety score intervention	6.3/21 ± 3.6	0.13	109	0.90	0.02
Anxiety score control	6.4/21 ± 3.7				
Three months					
Depression score intervention	2.8/21 ± 3.0	0.11	78	0.91	0.02
Depression score control	2.8/21 ± 3.4				
Anxiety score intervention	3.3/21 ± 3.1	0.43	78	0.67	0.10
Anxiety score control	3.6/21 ± 3.2				
Change in scores between discharge and 3 months					
Depression					
Intervention	0.8 ± 3.6 (range −8 to 10)	2.21	78	0.03	0.50
Control	2.4 ± 2.7 (range −2 to 7)				
Anxiety					
Intervention	2.8 ± 3.0 (range −9 to 9)	0.03	78	0.98	0.01
Control	2.8 ± 3.6 (range −4 to 10)				

No. of patients meeting cut-offs for symptoms

	Discharge	*p* value	Three months	*p* value
Depression (total)	16/111 (14.4%)		6/80 (7.5%)	
Intervention	4/61 (6.6%)	0.01	3/46 (6.5%)	0.70
Control	12/50 (24%)		3/34 (8.8%)	
Anxiety (total)	39/111 (35.1%)		9/80 (11.3%)	
Intervention	25/61 (41.0%)	0.15	5/46 (10.9%)	0.90
Control	14/50 (28%)		4/34 (11.8%)	

Attrition rate	No. of dropouts	*p* value
Total	31/111 (27.9%)	
Intervention	15/61 (24.6%)	0.39
Control	16/50 (32%)	

more patients in the control group met the cut-off for depressive symptoms at discharge. The reverse was true for anxiety symptoms; more patients in the intervention group met the cut-off at discharge. It appears that ACS is associated with more anxiety instead of depressive symptoms. The prevalence of depressive and anxiety symptoms drops to 7% and 11% at 3 months; however, part of this interpretation is limited by an attrition rate of 27%. Both groups had roughly the same proportions of participants meeting cut-offs for depressive or anxiety symptoms at 3 months.

It is notable that flowering plants affected depressive symptoms greater than anxiety; considering other randomised controlled trials have showed that flowering plants decrease anxiety symptoms [16–18]. We note, however, that in our study population, 13 patients had pre-existing depression, 5 had pre-existing anxiety, and 3 had both pre-existing conditions. Therefore, we may have had a higher baseline of depression in our study compared to other studies. There were also significantly more cases presenting with cardiac arrest in the intervention group, which may have increased the tendency towards depressive/anxiety symptoms.

One of the proposed mechanisms behind our result of less depressive symptoms at discharge with flowering plants is that they mediate a reduced response to stress through an increase in the perceived attractiveness of the room [20]. This is supported by a functional magnetic resonance imaging study showing increased activity in the anterior cingulate and insula (brain regions associated with higher empathy and altruistic behaviour), in contrast to the increased amygdala activity indicating increased stress when viewing busy urban scenery [30]. Another hypothesis is that views of nature provide a positive distraction for those in stressful situations [31] by imparting a positive mood and improving self-reported somatic discomfort [32, 33].

We note that in both the mITT and PP analyses, the mean difference in depressive and anxiety symptom scores was positive (indicating increase in scores) at the 3-month mark in both groups, despite a decrease or no change in absolute score. This is likely to be related to the fact that the discharge score was based on a slightly larger cohort of patients and that the 3-month score is based only on patients who completed both a discharge and 3-month questionnaire. The mean of changes in score from discharge to 3 months (based on the smaller cohort) is more representative of the available data at 3 months. In both the mITT and PP analyses, there was a larger change (increase) in mean depressive symptom scores at 3 months in the control group compared to the intervention group. This difference was significant in both analyses. On the other hand, the increase in anxiety scores was similar between groups.

There could be a few plausible explanations for the difference in results between discharge and at 3 months. Firstly, the effect of flowering plants could only be elicited when visually present to the patients, thus explaining its effect in hospital but not post-discharge; however, we cannot state this conclusively as we did not consider exposure to flowers in a home setting. Secondly, anxiety and depressive symptoms post hospital discharge may have decreased due to the passing of the ACS and its symptoms but increased in a proportion of cases due to fear of recurrence or ongoing non-cardiac medical problems (qualitative data provided spontaneously by patients during 3-month phone follow-up). The impact of flowering plants seems to be more marked during the admission compared to 3 months after ACS.

Plants as psychological therapies in medical intervention

A Cochrane review of psychological interventions in patients with coronary heart disease demonstrated improvements in depression and anxiety symptoms and cardiac mortality [34], though these did not reduce total deaths, risk of revascularization, or non-fatal infarction. However, these psychological interventions did not utilise flowering plants but rather addressed type A behaviours, cardiac risk factor education, client-led discussions and providing emotional support in the treatment process. It also concluded that there was a lack of high-quality evidence to confirm the observed benefits and that further targeted trials were required to fully assess the heterogenous interventions analysed.

There are several small randomised controlled trials examining the effect of indoor plants in hospital rooms on post-procedural anxiety and pain control in patients undergoing surgery, such as appendicectomy [16], thyroidectomy [18] and haemorrhoidectomy [17]. Indoor plants have beneficial effects on anxiety symptoms, based on the Spielberger State Trait Anxiety Inventory Y (STAI-Y) score and decreased self-reported pain intensity and/or distress. Similar positive results have been reported in studies of radiology waiting rooms and simple day procedures using other methods of pain measurement such as via a visual analogue scale [14, 15, 19].

However, most studies of plants and their positive psychological effects have been conducted on students or office workers, and the types of stressors faced by these groups may not reflect those experienced by hospital inpatients. There is also significant methodological heterogeneity in the literature, with variation in the types of plants used (flowering vs foliage), duration of exposure (hours vs days) [35], and outcome measures. This study, thus, provides a unique perspective into environmental strategies to reduce patient distress, and is the first to examine this effect in the ACS population (as opposed to pre-existing studies in post minor surgical patients).

Limitations

Our study is limited as it is a small-volume study; nonetheless, the fact that we included patients from two centres improves generalizability of results. The nature of our intervention also meant that we could not blind hospital staff or patients. Due to constraints of time and funding, we were unable to obtain suitable personnel for a clinical diagnostic psychiatric interview by a blinded outcomes assessor.

10 patients crossed over from the control to the intervention group as their next of kin brought flowers when visiting. This may be a proxy for protective social networks that may influence psychological outcomes and is also a potential confounding factor. However, we thought it was unethical to limit next of kin visits in our study and performed per-protocol analysis to remove cross-over cases in an attempt to reduce confounding.

We also did not use living plants, to which patients may have responded more positively compared to artificial plants. However, it is noteworthy that pictures of plants do not differ significantly from real plants in their capacity to elicit positive emotions, as demonstrated in a study by Beukeboom et al. in a radiology waiting room [14]. A recent local study in an oncology waiting room also showed that patients and staff generally reacted positively to greenery in the waiting room. Although 62% of participants stated that they preferred living plants, 76% strongly agreed that artificial plants were better than no plants at all [36].

With regards to other environmental factors, patients were placed in a single room at the start of their admission (as per coronary care unit practice to try and minimise external disturbance) before being moved to a four-bed cardiac telemetry monitored room. Sometimes, patients were moved to another single cardiac telemetry monitored room, depending on bed availability. We considered other confounders such as the amount of light in the room and décor; all patient rooms had moderately large windows with a view of the surrounding suburb and small parks and were all plain without any pictures. Televisions were supplied to all patients, but subscription to the service was optional.

Finally, our attrition rate may have affected our ability to show a difference between groups at 3 months post discharge.

Conclusions

Indoor flowering plants in the rooms of post-ACS patients in coronary care during their inpatient period reduced patient depressive symptoms in a per-protocol analysis but had no effect on anxiety HADS score at discharge. A large proportion of patients (73%) demonstrated mild increases in depression and anxiety symptom scores at 3 months; however, there was a significantly larger increase in the control group compared to the intervention group in both modified intention-to-treat and per-protocol analyses.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to report.

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