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Nurse-Led Integrative Spiritual Care and Pandanus Amaryllifolius Aromatherapy for Psychophysiological Stress and Quality of Recovery after Cardiac Surgery: A Controlled Quasi-Experimental Study

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ABSTRACT:

Objective: To evaluate the effects of a nurse-led integrative intervention combining spiritual care and *Pandanus amaryllifolius* aromatherapy on psychophysiological stress and postoperative quality of recovery among patients undergoing elective cardiac surgery.

Methods: This prospective controlled quasi-experimental study was conducted at RSUD Siti Fatimah (Siti Fatimah Regional General Hospital), South Sumatra Province, Indonesia, from March to June 2026. Eighty-four adults undergoing elective cardiac surgery were consecutively recruited and assigned to an intervention group receiving nurse-led spiritual care plus *P. amaryllifolius* aromatherapy in addition to standard perioperative care (n=42) or a control group receiving standard care alone (n=42). Anxiety was assessed using the Amsterdam Preoperative Anxiety and Information Scale (APAIS), physiological stress using heart rate, blood pressure, mean arterial pressure, respiratory rate, and SpO_2, and postoperative recovery using the Quality of Recovery-15 (QoR-15). Baseline-adjusted analyses were performed.

Results: APAIS scores decreased from 14.2 ± 3.1 to 8.3 ± 2.7 in the intervention group and from 14.5 ± 3.3 to 12.7 ± 3.1 in controls, with an adjusted mean difference of −4.0 points (95% CI −5.1 to −2.9; $p<0.001$). Significant intervention effects were also observed for heart rate, systolic blood pressure, and mean arterial pressure. QoR-15 scores were higher in the intervention group than controls (122.6 ± 12.4 vs 111.3 ± 13.7), with an adjusted difference of 10.8 points (95% CI 5.3–16.3; $p<0.001$).

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Conclusion: Nurse-led spiritual care combined with *P. amaryllifolius* aromatherapy was associated with lower perioperative psychophysiological stress and better postoperative recovery after cardiac surgery.

1. INTRODUCTION

Cardiac surgery remains an essential therapeutic strategy for advanced cardiovascular disease, yet the perioperative period exposes patients to substantial psychological and physiological stress. Preoperative anxiety is common among surgical patients and is increasingly recognized as clinically relevant because it has been associated with greater anesthetic and analgesic requirements, increased postoperative pain, delirium, and delayed recovery [1]. In cardiac surgery specifically, perioperative anxiety and depression have been associated with increased late mortality, indicating that psychological distress may have consequences beyond transient emotional discomfort [2]. Psychophysiologically, preoperative and surgical stress activates the hypothalamic–pituitary–adrenal axis, sympathetic–adrenomedullary system, autonomic nervous system, and inflammatory signaling, producing changes in cortisol secretion, cardiovascular responses, pain modulation, metabolic regulation, and immune activity [3]. These responses are particularly important in cardiac surgery because surgical trauma, cardiopulmonary bypass, blood contact with extracorporeal surfaces, ischemia–reperfusion injury, and oxidative stress independently provoke systemic inflammatory activation [4-6]. Thus, perioperative stress represents a multidimensional and potentially modifiable process in which psychological distress may interact with autonomic, endocrine, and inflammatory responses to influence postoperative recovery.

Perioperative nurses are strategically positioned to address these interconnected responses because they provide continuous care before surgery and throughout acute postoperative recovery. Their role extends beyond physiological surveillance to psychological preparation, therapeutic communication, symptom management, education, spiritual support, and structured non-pharmacological interventions. In patients undergoing cardiac surgery, nurse-led preoperative education has been shown to reduce anxiety and selected postoperative complications [7], while systematic review and meta-analytic evidence further supports preoperative educational interventions for improving perioperative outcomes in this population [8]. More recent evidence demonstrates that nurse-led interventions across adult cardiac surgical care can improve comfort, physiological stability, symptom control, mobilization, and aspects of functional recovery, although important gaps remain in high-quality nursing intervention research [9]. Similarly, a 2026 systematic review and meta-analysis involving 1,827 surgical patients found that perioperative nurse-led psychological interventions significantly reduced both preoperative and postoperative anxiety and improved patient satisfaction [10]. These findings reinforce the role of nurses not merely as implementers of perioperative medical treatment but as leaders of evidence-based, person-centered interventions capable of targeting modifiable determinants of surgical recovery.

Spiritual care represents a particularly relevant dimension of this nursing role because major cardiac surgery may confront patients with uncertainty regarding survival, fear of death, perceived loss of control, disruption of meaning, and concerns about future functioning. Culturally congruent spiritual care may promote meaning, hope, acceptance, emotional security, religious coping, and adaptation to illness. A randomized controlled trial among Muslim patients undergoing coronary artery bypass grafting demonstrated that a preoperative spiritual/religious intervention significantly reduced anxiety [11], while another randomized pilot study in CABG patients showed that Islamic spiritual intervention influenced anxiety and depression, with psychophysiological outcomes also explored through heart-rate-variability-related measures [12]. Systematic evidence in patients with heart disease further suggests that Islamic spiritual care may improve depression and quality of life [13], and a recent review specifically examining nurse-led spiritual care in cardiovascular populations reported potentially beneficial psychological effects while emphasizing heterogeneity in interventions and the need for stronger studies [14]. Moreover, a systematic review and meta-analysis of randomized trials involving patients with cardiovascular disease found that spiritual and religious interventions were associated with reductions in anxiety, depression, and heart rate and improvements in spiritual well-being and hope [15]. However, most existing cardiovascular spiritual-care research has emphasized psychological, spiritual, or quality-of-life outcomes rather than integrating spiritual care with a natural sensory intervention to evaluate broader perioperative psychophysiological stress and patient-centered postoperative recovery.

Aromatherapy may provide a complementary sensory component within such an integrative nursing intervention. Meta-analytic evidence indicates that plant-derived aromatherapy can reduce preoperative anxiety, although methodological heterogeneity remains substantial [16,17]. More recent evidence comparing aromatherapy with other complementary modalities also supports its potential role in perioperative anxiety management while demonstrating variability in physiological and pain-related outcomes. Importantly, the existing evidence is dominated by a relatively narrow range of aromatic agents, particularly lavender, citrus-derived preparations, and rose [18], creating a rationale for evaluating culturally relevant but less extensively investigated natural resources. *Pandanus amaryllifolius* Roxb., or fragrant pandan, is widely cultivated and traditionally used throughout Southeast Asia, including Indonesia. Contemporary phytochemical research has identified more than 100 constituents in *P. amaryllifolius*, including alkaloids, phenolics, organic acids, terpenoids, pigments, and volatile compounds [19]. Its distinctive aroma is strongly associated with 2-acetyl-1-pyrroline (2AP), while analytical studies have demonstrated a broader volatile profile within pandan leaves [20]. Recent reviews further describe pandan as a source of flavonoids, phenolic acids, alkaloids, carotenoids, tocopherols, chlorophyll derivatives, and other potentially bioactive constituents, while emphasizing the continuing need for well-designed human intervention studies [21]. Earlier analytical work also established *P. amaryllifolius* as an important natural source of 2AP and characterized additional volatile constituents [22]. Therefore, although the phytochemical and aromatic basis of pandan is well established, evidence that inhaled *P. amaryllifolius* specifically reduces psychophysiological stress or enhances recovery after cardiac surgery remains insufficient. Its incorporation in the present study should consequently be regarded as an innovative, culturally relevant natural-resource-based intervention requiring clinical evaluation rather than as an already established therapy.

Despite growing evidence supporting nurse-led perioperative care, spiritual interventions, aromatherapy, and patient-reported recovery assessment, limited research has examined an integrative nursing intervention that combines culturally congruent spiritual care with *Pandanus amaryllifolius* aromatherapy in cardiac surgical patients. The Quality of Recovery-15 (QoR-15), a validated multidimensional patient-reported measure encompassing physical comfort, emotional state, psychological support, physical independence, and pain, has demonstrated strong validity, reliability, responsiveness, and clinical utility across surgical populations [23-25], with recent evidence confirming its feasibility and responsiveness specifically after cardiac surgery [26, 27]. The novelty of this study lies in integrating a structured nurse-led spiritual intervention with a culturally relevant Southeast Asian plant-derived aromatherapy while simultaneously evaluating psychophysiological stress and postoperative quality of recovery rather than anxiety alone. Therefore, this study aimed to investigate the effects of nurse-led integrative spiritual care combined with *P. amaryllifolius* aromatherapy on psychophysiological stress and postoperative quality of recovery in patients undergoing cardiac surgery. It was hypothesized that patients receiving the integrative intervention would experience lower psychophysiological stress and better postoperative quality of recovery than those receiving standard perioperative care.

2. MATERIALS AND METHODS

2.1. Study Design and Setting

This study employed a prospective, controlled quasi-experimental design with two parallel groups and a non-equivalent control group. The study was conducted at RSUD Siti Fatimah (Siti Fatimah Regional General Hospital), South Sumatra Province, Indonesia, between March and June 2026. The intervention group received nurse-led integrative spiritual care combined with *Pandanus amaryllifolius* aromatherapy in addition to standard perioperative care, while the control group received standard perioperative care only. A summary of the study procedures and participant flow is provided in Figure 1. Reporting of the study followed the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guidelines [28,29].

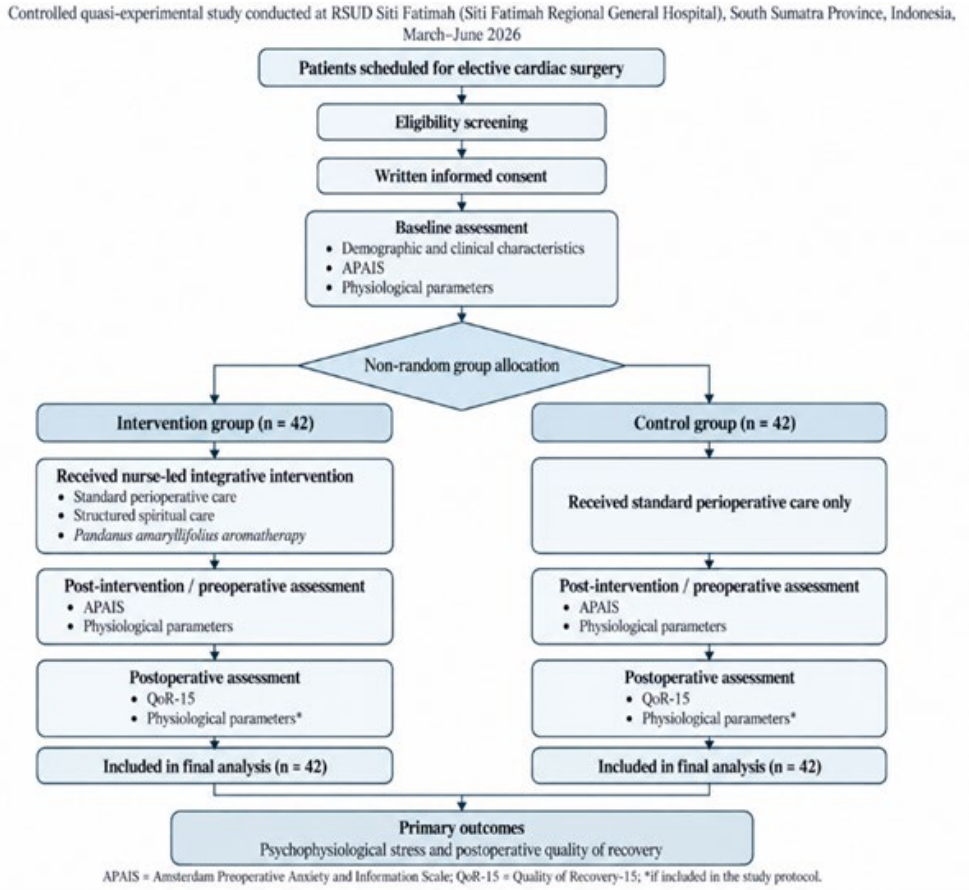


Figure 1. Study design and participant flow

2.2. Participants and Sampling

The study included 84 adult patients undergoing elective cardiac surgery, comprising 42 participants in the intervention group and 42 in the control group. Eligible participants were recruited consecutively during the study period. Participants were included if they were aged ≥18 years, scheduled for elective cardiac surgery, conscious and clinically stable, able to communicate effectively and complete the study instruments, and willing to provide written informed consent. Patients were excluded if they had severe cognitive impairment, acute psychiatric disorders, hemodynamic instability requiring urgent management, underwent emergency surgery, had a known hypersensitivity to aromatic plant products, or had respiratory conditions that could potentially be aggravated by inhalational exposure. All eligible patients received an explanation of the study objectives, procedures, potential benefits and risks, confidentiality safeguards, and their right to withdraw at any time without affecting the care they received. Written informed consent was obtained before baseline assessment and study participation.

2.3. Group Allocation

Because this was a quasi-experimental study, participants were not randomly assigned. Eligible patients were allocated to the intervention or control group according to the predefined non-random allocation procedure used during recruitment. Identical eligibility criteria and baseline assessments were applied to both groups. To reduce contamination, structured spiritual-care sessions and *P. amaryllifolius* aromatherapy were delivered only to the intervention group. Any baseline imbalance between groups was considered in adjusted statistical analyses.

2.4. Nurse-Led Integrative Intervention

The intervention combined two components: structured nurse-led spiritual care and *P. amaryllifolius* aromatherapy. Both components were delivered by trained nurses using a standardized intervention checklist to maintain consistency.

2.4.1. Spiritual Care

The spiritual-care component was delivered by trained nurses using a standardized, person-centered protocol. It included therapeutic presence and active listening, exploration of surgery-related fears and concerns, reinforcement of hope and adaptive coping, guided spiritual reflection, and facilitation of prayer or *dhikr* according to each participant's preferences and spiritual needs. The intervention was culturally sensitive and individualized, and no specific religious practice was imposed. Intervention fidelity was monitored using a standardized checklist documenting the components delivered, participant engagement, session duration, and any protocol deviations.

2.4.2. *Pandanus amaryllifolius* Aromatherapy

The aromatherapy component used *Pandanus amaryllifolius* as a plant-derived inhalational intervention administered according to a standardized protocol. The intervention procedure specified the botanical source and plant part used, preparation or extraction method, concentration, administered volume or dose, delivery device, distance from the patient, duration and frequency of exposure, timing in relation to surgery, and storage conditions. Aromatherapy was administered under nurse supervision in a controlled clinical setting. Participants were observed throughout the exposure for potential adverse effects, including dizziness, nausea, headache, respiratory discomfort, mucosal irritation, or allergic reactions. The intervention was immediately discontinued if any clinically relevant adverse response occurred.

2.5. Control Group

Participants in the control group received standard perioperative nursing and medical care according to hospital procedures, including routine preoperative preparation, monitoring, medication administration, patient education, pain management, respiratory care, mobilization, and postoperative observation. The control group did not receive the structured spiritual-care protocol or *P. amaryllifolius* aromatherapy during the study period.

2.6. Psychophysiological Stress Assessment

Psychophysiological stress was assessed using psychological and physiological measures.

2.6.1. Psychological Component

Preoperative anxiety was assessed using the Amsterdam Preoperative Anxiety and Information Scale (APAIS). The APAIS contains six items: four assess anxiety related to anesthesia and surgery, and two assess the need for information. Each item is scored on a five-point Likert scale, with higher anxiety scores indicating greater preoperative anxiety. The APAIS was administered at baseline before the intervention and repeated after completion of the intervention but before surgery.

2.6.2. Physiological Component

Physiological stress was evaluated using routinely measured perioperative parameters, including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, respiratory rate, and peripheral oxygen saturation. Measurements were obtained under standardized resting conditions using calibrated hospital monitoring equipment. Baseline values were obtained before intervention exposure, and post-intervention values were recorded using the same measurement procedure. If biomarkers such as heart-rate variability, salivary cortisol, C-reactive protein, or interleukin-6 were actually measured, they should be reported separately with sampling time, assay method, storage procedure, and laboratory analysis.

2.7. Quality of Recovery

Postoperative recovery was assessed using the Quality of Recovery-15 (QoR-15) questionnaire. The QoR-15 contains 15 items covering physical comfort, emotional state, psychological support, physical independence, and pain. Each item is rated from 0 to 10, giving a total score of 0–150. Higher scores indicate better postoperative recovery. The QoR-15 has demonstrated strong validity and responsiveness in surgical populations and has recently been validated specifically in cardiac surgery. QoR-15 was administered during the early postoperative period at the prespecified time point used in the study protocol. If the study used 48 hours after surgery, this timing should be stated explicitly because cardiac-surgery validation studies have demonstrated good reliability at this time point.

2.8. Outcome Measures and Assessment Schedule

The primary outcomes were psychophysiological stress and postoperative quality of recovery. Anxiety and physiological parameters were assessed before and after the intervention, whereas QoR-15 was measured postoperatively. The timing of all assessments is summarized in Table 1.

Table 1. Intervention and outcome assessment schedule

Variable	Baseline	Post-intervention / Preoperative	Postoperative
Demographic and clinical data	✓	—	—
APAIS	✓	✓	—
Heart rate	✓	✓	✓*
Blood pressure/MAP	✓	✓	✓*
Respiratory rate	✓	✓	✓*
SpO_2	✓	✓	✓*
Intervention adherence	—	✓	—
Adverse events	—	✓	✓
QoR-15	—	—	✓

*If included in the actual study protocol.

2.9. Intervention Fidelity and Safety

Intervention fidelity was maintained through standardized nurse training, a written intervention protocol, and a structured checklist. Nurses documented completion of spiritual-care components, aromatherapy administration, participant adherence, interruptions, and protocol deviations. All adverse events potentially related to aromatherapy were recorded. Participants experiencing respiratory discomfort, nausea, dizziness, headache, or allergic symptoms were withdrawn from aromatherapy exposure and clinically evaluated.

2.10. Statistical Analysis

Continuous variables were summarized as mean ± standard deviation or median and interquartile range, according to distribution. Categorical variables were reported as frequencies and percentages. Baseline group differences were assessed using independent-samples *t*-tests or Mann–Whitney *U* tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. For outcomes measured before and after the intervention, analysis of covariance (ANCOVA) was used with the post-intervention score as the dependent variable, study group as the main predictor, and baseline score as a covariate. Where outcomes were measured at three or more time points, a linear mixed-effects model was used to estimate group, time, and group-by-time interaction effects. Because allocation was nonrandomized, clinically relevant baseline variables and variables showing meaningful imbalance between groups were included as covariates where appropriate. Results were reported as adjusted mean differences, effect sizes, 95% confidence intervals, and two-sided *p*-values. Statistical significance was set at $p < 0.05$.

2.11. Bias Control

Bias was minimized by applying identical eligibility criteria to both groups, conducting baseline measurements before intervention exposure, using standardized instruments and procedures, and adjusting for relevant baseline differences in statistical analyses. Participant and intervention-provider blinding was not feasible because of the nature of the intervention. However, standardized outcome assessment and objective physiological measurements were used to reduce measurement bias.

3. RESULTS AND DISCUSSION

3.1. Participant Flow and Baseline Characteristics

A total of 84 patients undergoing elective cardiac surgery were included in the study, with 42 participants in the intervention group and 42 in the control group. All enrolled participants completed the baseline assessment and were included in the final analysis. The participant flow from eligibility assessment through outcome evaluation is presented in **Figure 1**.

At baseline, the intervention and control groups were comparable in demographic, clinical, and psychophysiological characteristics. No statistically significant between-group differences were observed in age, sex, cardiovascular diagnosis, type of cardiac surgery, comorbidities, baseline APAIS score, heart rate, blood pressure, respiratory rate, or peripheral oxygen saturation.

Table 1. Baseline demographic and clinical characteristics of participants

Characteristic	Intervention (n = 42)	Control (n = 42)	*p*-value
Age, years, mean ± SD	58.6 ± 8.4	59.2 ± 8.9	0.751
Male, n (%)	27 (64.3)	26 (61.9)	0.821
Female, n (%)	15 (35.7)	16 (38.1)	
Coronary artery disease, n (%)	30 (71.4)	29 (69.0)	0.811
Valvular heart disease, n (%)	12 (28.6)	13 (31.0)	
CABG, n (%)	29 (69.0)	28 (66.7)	0.817
Valve surgery, n (%)	13 (31.0)	14 (33.3)	
Hypertension, n (%)	24 (57.1)	25 (59.5)	0.825
Diabetes mellitus, n (%)	15 (35.7)	14 (33.3)	0.817
APAIS anxiety score, mean ± SD	14.2 ± 3.1	14.5 ± 3.3	0.667
Heart rate, beats/min	88.7 ± 10.2	89.4 ± 10.6	0.758
Systolic BP, mmHg	142.8 ± 15.6	144.1 ± 16.1	0.707
Diastolic BP, mmHg	84.7 ± 9.4	85.3 ± 9.7	0.774
Mean arterial pressure, mmHg	104.1 ± 10.5	104.9 ± 10.8	0.731
Respiratory rate, breaths/min	20.8 ± 2.6	21.0 ± 2.8	0.735
SpO_2, %	97.1 ± 1.4	97.0 ± 1.5	0.753

Values are presented as mean ± SD or n (%), as appropriate.

Based on Table 1, the intervention and control groups showed similar baseline demographic, clinical, and psychophysiological profiles. All baseline comparisons yielded p values >0.05, indicating no statistically significant differences between groups before the intervention. This baseline comparability reduces the likelihood that subsequent differences in anxiety, physiological stress responses, or postoperative recovery were primarily attributable to pre-existing group differences.

3.2. Effect on Preoperative Anxiety

Preoperative anxiety decreased in both groups, but the reduction was substantially greater among patients receiving nurse-led integrative spiritual care combined with *Pandanus amaryllifolius* aromatherapy. In the intervention group, the mean APAIS

anxiety score decreased from 14.2 ± 3.1 at baseline to 8.3 ± 2.7 after the intervention. In comparison, the control group showed a smaller reduction from 14.5 ± 3.3 to 12.7 ± 3.1.

Table 2. Changes in APAIS anxiety scores before and after intervention

Anxiety outcome	Intervention	Control	Between-group effect
Baseline, mean ± SD	14.2 ± 3.1	14.5 ± 3.3	$p = 0.667$
Post-intervention, mean ± SD	8.3 ± 2.7	12.7 ± 3.1	$p < 0.001$
Mean change	−5.9	−1.8	-
Adjusted mean difference	-	-	−4.0
95% CI	-	-	−5.1 to −2.9
Cohen's *d*	-	-	−1.38
p-value			<0.001

Based on Table 2, the intervention group experienced a markedly greater reduction in preoperative anxiety than the control group. The adjusted mean difference of −4.0 points (95% CI −5.1 to −2.9; $p < 0.001$) indicates a statistically significant effect favoring the nurse-led integrative intervention. The Cohen's *d* of −1.38 suggests a large standardized effect, indicating that the observed reduction was not only statistically significant but also potentially clinically meaningful. The pattern of change in APAIS scores is illustrated in Figure 2, showing a steeper decline in anxiety scores in the intervention group than in the control group.

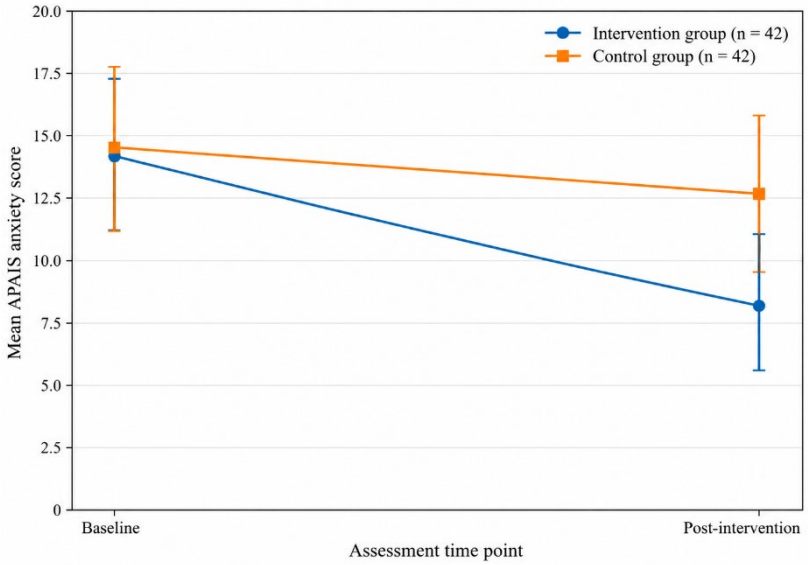


Figure 2. Mean APAIS anxiety scores before and after intervention in the intervention and control groups.

3.3. Effect on Physiological Stress Responses

The intervention was also associated with more favorable physiological stress responses before surgery. Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and respiratory rate decreased more markedly in the intervention group, whereas peripheral oxygen saturation remained stable in both groups.

Table 3. Changes in physiological stress parameters

Parameter	Intervention baseline	Intervention post	Control baseline	Control post	Adjusted effect (95% CI)	*p*-value
Heart rate, beats/min	88.7 ± 10.2	79.8 ± 8.6	89.4 ± 10.6	86.7 ± 9.8	−6.4 (−9.8 to −3.0)	<0.001
Systolic BP, mmHg	142.8 ± 15.6	130.9 ± 13.8	144.1 ± 16.1	139.6 ± 15.2	−8.1 (−13.3 to −2.9)	0.003
Diastolic BP, mmHg	84.7 ± 9.4	78.2 ± 8.5	85.3 ± 9.7	82.7 ± 9.1	−4.1 (−7.3 to −0.9)	0.013
Mean arterial pressure, mmHg	104.1 ± 10.5	95.8 ± 9.6	104.9 ± 10.8	101.7 ± 10.1	−5.7 (−9.3 to −2.1)	0.002
Respiratory rate, breaths/min	20.8 ± 2.6	18.6 ± 2.1	21.0 ± 2.8	20.2 ± 2.5	−1.4 (−2.3 to −0.5)	0.003
SpO_2, %	97.1 ± 1.4	97.5 ± 1.2	97.0 ± 1.5	97.2 ± 1.4	+0.3 (−0.2 to 0.8)	0.231

Based on Table 3, the intervention was associated with significant reductions in heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and respiratory rate compared with standard perioperative care. The largest adjusted differences were observed for systolic blood pressure (−8.1 mmHg) and heart rate (−6.4 beats/min). In contrast, the change in SpO_2 was not statistically significant ($p = 0.231$), indicating that the intervention influenced stress-related cardiovascular and respiratory parameters without materially altering oxygen saturation. The principal physiological changes are summarized in Figure 3, illustrating the greater reductions in heart rate and mean arterial pressure in the intervention group.

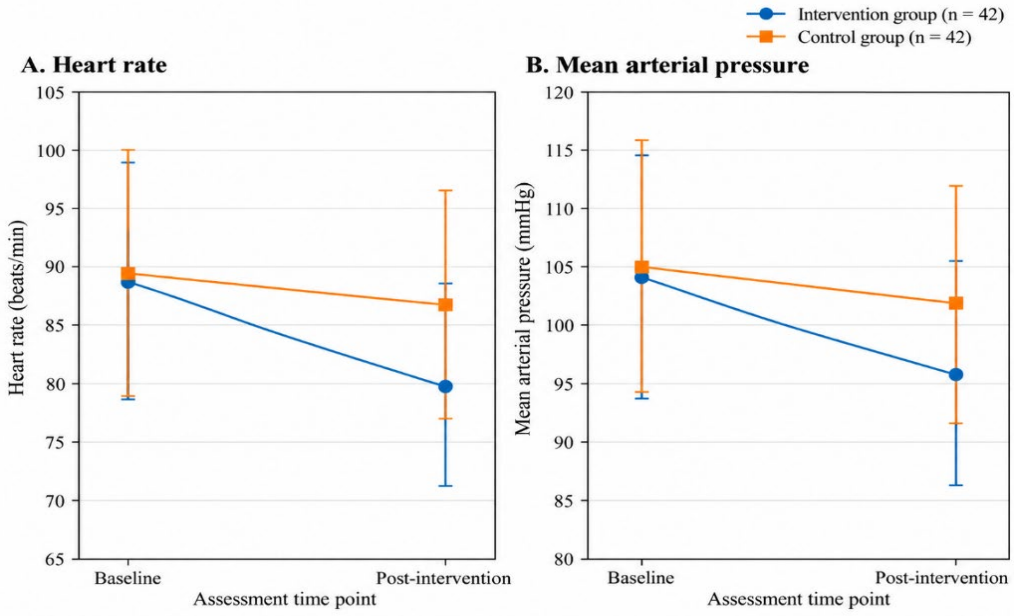


Figure 3. Changes in heart rate and mean arterial pressure before and after intervention between study groups.

3.4. Postoperative Quality of Recovery

Patients receiving the nurse-led integrative intervention reported better postoperative recovery than those receiving standard perioperative care. The mean total QoR-15 score was 122.6 ± 12.4 in the intervention group compared with 111.3 ± 13.7 in the control group.

Table 4. Postoperative Quality of Recovery-15 outcomes

QoR-15 domain	Intervention	Control	Adjusted difference (95% CI)	*p*-value
Total QoR-15 score	122.6 ± 12.4	111.3 ± 13.7	10.8 (5.3–16.3)	<0.001
Physical comfort	42.1 ± 5.4	38.0 ± 5.9	3.8 (1.4–6.2)	0.002
Emotional state	28.4 ± 4.1	24.7 ± 4.8	3.5 (1.6–5.4)	<0.001
Psychological support	17.2 ± 2.3	15.5 ± 2.7	1.6 (0.5–2.7)	0.004
Physical independence	16.1 ± 3.2	15.0 ± 3.4	1.0 (−0.4 to 2.4)	0.156
Pain	18.8 ± 3.4	18.1 ± 3.6	0.7 (−0.8 to 2.2)	0.349

Based on Table 4, patients in the intervention group achieved significantly higher overall QoR-15 scores than those in the control group. The adjusted between-group difference in the total score was 10.8 points (95% CI 5.3–16.3; $p < 0.001$), indicating better overall postoperative recovery following the integrative intervention. Significant improvements were observed in physical comfort, emotional state, and psychological support. However, differences in physical independence and pain did not reach statistical significance, suggesting that the intervention may have had a stronger influence on emotional, psychological, and comfort-related dimensions of recovery than on early functional independence or pain perception. The between-group difference in overall postoperative quality of recovery is illustrated in Figure 4.

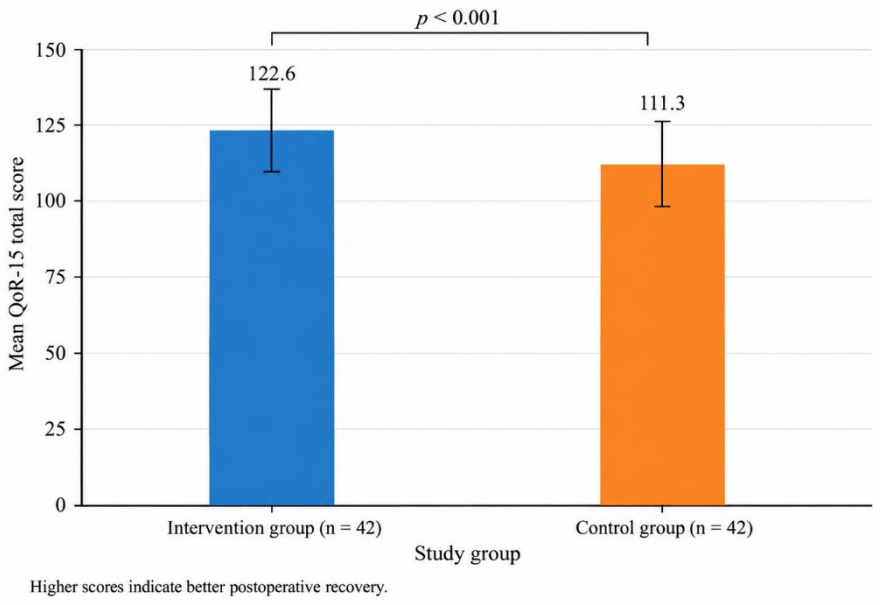


Figure 4. Mean postoperative QoR-15 total scores in the intervention and control groups.

3.5. Adjusted Intervention Effects

Because group allocation was nonrandomized, adjusted analyses were conducted using analysis of covariance to account for baseline outcome values and relevant clinical characteristics.

Table 5. Adjusted effects of the nurse-led integrative intervention

Outcome	Adjusted effect (β)	95% CI	*p*-value	Interpretation
APAIS anxiety score	−4.0	−5.1 to −2.9	<0.001	Favors intervention
Heart rate	−6.4	−9.8 to −3.0	<0.001	Favors intervention

Systolic BP	−8.1	−13.3 to −2.9	0.003	Favors intervention
Mean arterial pressure	−5.7	−9.3 to −2.1	0.002	Favors intervention
QoR-15 total score	+10.8	5.3 to 16.3	<0.001	Favors intervention

Based on Table 5, the beneficial effects of the intervention remained statistically significant after adjustment for baseline values and relevant covariates. The intervention was independently associated with lower anxiety, heart rate, systolic blood pressure, and mean arterial pressure, as well as higher postoperative QoR-15 scores. The consistency between unadjusted and adjusted estimates strengthens the evidence that the observed differences were associated with the nurse-led integrative intervention rather than baseline imbalance alone.

3.6. Intervention Fidelity and Safety

Intervention fidelity was high, with most participants completing the prescribed spiritual-care and aromatherapy components.

Table 6. Intervention adherence and safety

Indicator	**Intervention group (n = 42)**
Completed full intervention, n (%)	39 (92.9)
Completed ≥80% of intervention components, n (%)	41 (97.6)
Protocol deviations, n (%)	1 (2.4)
Mild adverse events, n (%)	2 (4.8)
Aromatherapy discontinued, n (%)	0 (0.0)
Serious adverse events, n (%)	0 (0.0)

Based on Table 6, adherence to the intervention protocol was high, with 92.9% of participants completing the entire intervention and 97.6% completing at least 80% of its components. Only one protocol deviation was recorded. Two participants experienced mild transient adverse symptoms, representing 4.8% of the intervention group, while no intervention discontinuation or serious adverse events occurred. These findings indicate that the combined nurse-led spiritual-care and *P. amaryllifolius* aromatherapy intervention was feasible and generally well tolerated in the perioperative cardiac surgical setting. Overall, the findings demonstrated a consistent pattern favoring nurse-led integrative spiritual care combined with *P. amaryllifolius* aromatherapy. The intervention was associated with lower preoperative anxiety, more favorable cardiovascular and respiratory stress responses, and better patient-reported postoperative quality of recovery compared with standard perioperative care.

4 DISCUSSION

4.1 Principal Findings

This study demonstrated that a nurse-led integrative intervention combining structured spiritual care with *Pandanus amaryllifolius* aromatherapy was associated with lower preoperative psychophysiological stress and better postoperative quality of recovery among patients undergoing elective cardiac surgery. Compared with standard perioperative care, the intervention group showed a greater reduction in APAIS anxiety scores, heart rate, systolic and diastolic blood pressure, mean arterial pressure, and respiratory rate. The intervention group also achieved higher postoperative QoR-15 scores, particularly in physical comfort, emotional state, and psychological support. These findings remained significant after adjustment for baseline measures, supporting the potential clinical value of an integrative, nurse-led perioperative approach.

The findings are consistent with evidence that structured non-pharmacological interventions can influence both psychological and physiological responses in cardiovascular patients. A systematic review and meta-analysis of inhalational aromatherapy in cardiac surgery reported reductions in anxiety, postoperative pain, and heart rate, although effects on blood pressure were less consistent [30]. Similar benefits have been reported in broader cardiovascular populations, where aromatherapy was

associated with reductions in anxiety, systolic blood pressure, heart rate, and respiratory rate [31]. These findings support the present observation that perioperative stress may be responsive to appropriately structured complementary interventions.

4.2. Effect on Preoperative Anxiety

The marked reduction in preoperative anxiety observed in the intervention group is clinically important because patients awaiting cardiac surgery frequently experience fear of death, uncertainty regarding surgical outcomes, loss of control, postoperative pain, and concerns about functional recovery. Spiritual care may reduce these stressors by strengthening hope, acceptance, emotional security, meaning, and adaptive coping. Previous cardiovascular research supports this interpretation. Hosseini et al. demonstrated that a preoperative spiritual and religious intervention significantly reduced anxiety among Muslim patients undergoing coronary artery bypass graft surgery [32]. Amjadian et al. similarly reported improvements in anxiety and depression following an Islamic spiritual intervention among CABG patients and explored accompanying psychophysiological effects through heart-rate variability [33]. More recent systematic evidence indicates that nurse-led spiritual care can improve psychological well-being in patients with cardiovascular disease [34], while meta-analytic evidence suggests that spiritual and religious interventions may reduce anxiety, depression, and heart rate while improving hope and spiritual well-being [35].

The nursing context is likely important. Nurse-led perioperative psychological interventions have increasingly been shown to reduce anxiety and enhance patient satisfaction [36]. The effect observed in the present study may therefore reflect not only the spiritual content itself but also therapeutic presence, active listening, structured communication, reassurance, and culturally responsive nursing support.

4.3. Contribution of *Pandanus amaryllifolius* Aromatherapy

A distinctive feature of the present study is the use of *P. amaryllifolius* rather than more extensively studied aromatherapy agents such as lavender, rose, or citrus oils. Previous cardiac-surgery research has shown that inhalational aromatherapy using rose and lavender can reduce anxiety and surgical-site pain and may influence extubation-related outcomes [37]. Peppermint aromatherapy has also been reported to reduce anxiety among patients with acute coronary syndrome [38], and aromatherapy before coronary angiography has demonstrated beneficial effects on anxiety and pain [39].

Unlike these frequently studied agents, *P. amaryllifolius* is a culturally familiar Southeast Asian plant with a distinctive volatile profile. Phytochemical research has identified numerous bioactive constituents in the plant, including alkaloids, phenolics, terpenoids, and characteristic volatile compounds [40]. Its characteristic fragrance is strongly associated with 2-acetyl-1-pyrroline, and analytical research has demonstrated the presence of multiple additional volatile constituents [41].

Nevertheless, the present findings should not be interpreted as definitive evidence that *P. amaryllifolius* itself has a specific anxiolytic pharmacological effect. Human clinical evidence for inhaled *P. amaryllifolius* remains limited. A more appropriate interpretation is that the plant functioned as a culturally relevant olfactory component within a multimodal nursing intervention. The observed effect may therefore reflect a combination of olfactory stimulation, familiarity, relaxation, expectancy, therapeutic interaction, and spiritual support.

4.4. Effects on Physiological Stress Responses

The reductions in heart rate, blood pressure, mean arterial pressure, and respiratory rate suggest that the intervention may have influenced physiological arousal in addition to subjective anxiety. This finding is clinically plausible because anxiety and surgical stress activate sympathetic and neuroendocrine pathways that can increase cardiovascular workload.

The physiological pattern observed is broadly consistent with existing aromatherapy research. A meta-analysis in cardiovascular populations found that inhalational aromatherapy was associated with reductions in heart rate, respiratory rate, systolic blood pressure, and anxiety, although effects varied according to intervention and population [42]. A randomized trial using lemon verbena aromatherapy also demonstrated reductions in anxiety and several hemodynamic parameters before surgery [43]. Similar psychophysiological effects have been observed with non-pharmacological sensory interventions such as perioperative music therapy in cardiac surgical patients [44].

The absence of a significant effect on SpO_2 is not unexpected. Oxygen saturation is generally maintained within a narrow range in clinically stable elective surgical patients and may be less responsive to changes in psychological arousal than heart

rate or blood pressure. Accordingly, the lack of change in SpO_2 does not negate the broader psychophysiological effects observed.

4.5. Postoperative Quality of Recovery

Another important finding was the higher postoperative QoR-15 score among patients receiving the integrative intervention. This suggests that the intervention may have influenced not only preoperative stress but also patients' subjective experience of early postoperative recovery. QoR-15 is increasingly used as a patient-centered measure of postoperative recovery because it captures dimensions such as physical comfort, emotional state, psychological support, physical independence, and pain. Recent prospective evidence has demonstrated that QoR-15 is feasible, valid, and responsive specifically in cardiac surgical patients [45]. The stronger effects observed in emotional state, psychological support, and physical comfort are consistent with the intervention's content, which was designed primarily to address spiritual, emotional, and sensory dimensions of the perioperative experience.

By contrast, the absence of significant differences in physical independence and pain is also clinically plausible. These outcomes are strongly influenced by surgical complexity, sternotomy-related discomfort, cardiopulmonary bypass exposure, ventilation duration, analgesic strategy, and postoperative mobilization. A recent randomized study evaluating cardiac-surgery prehabilitation also showed that not all perioperative interventions translate into early improvement in QoR-15 scores, highlighting the complexity of postoperative recovery [46].

4.6. Integrative Nursing Perspective

The intervention can be understood within a biopsychospiritual nursing framework. Spiritual care addresses meaning, hope, acceptance, coping, and perceived support, whereas aromatherapy provides a complementary sensory stimulus. Together, these components may reduce threat perception and physiological arousal while enhancing comfort and emotional security. The nurse-led nature of the intervention is particularly important. Nurses are positioned throughout the perioperative trajectory and are therefore able to identify anxiety, assess spiritual needs, provide therapeutic communication, deliver non-pharmacological interventions, and monitor physiological responses. A recent systematic review of nurse-led interventions in adult cardiac surgery found that nursing interventions can improve comfort, physiological stability, symptom management, mobilization, and aspects of functional recovery [47, 48]. However, mechanisms such as autonomic regulation, HPA-axis modulation, or inflammatory attenuation remain hypothetical in the present study because HRV, cortisol, CRP, IL-6, or other mechanistic biomarkers were not directly assessed. These pathways should therefore be investigated in future trials rather than inferred as confirmed biological mechanisms.

4.7. Clinical Implications

The findings have several implications for perioperative cardiovascular nursing. First, psychological and spiritual assessment may be incorporated more systematically into preoperative nursing care, particularly for patients experiencing marked anxiety. Second, structured spiritual care can be provided as a preference-sensitive, culturally congruent adjunct without replacing established medical, anesthetic, or analgesic management. Third, *P. amaryllifolius* aromatherapy may offer a culturally relevant complementary intervention, provided that botanical identification, formulation, concentration, exposure duration, and safety procedures are standardized. Its use should remain adjunctive rather than substitutive. Finally, the combined use of APAIS, physiological parameters, and QoR-15 demonstrates the value of evaluating nursing interventions across psychological, physiological, and patient-reported recovery domains. Such multidimensional outcome assessment strengthens the contribution of nursing science to perioperative cardiovascular care.

4.8. Strengths and Limitations

This study has several strengths. It evaluated a nurse-led integrative intervention in a real cardiac surgical setting and assessed both psychological and physiological responses together with a validated patient-reported recovery measure. The intervention was culturally contextualized, standardized, and accompanied by monitoring of intervention fidelity and safety. Adjusted analyses were also used to account for baseline differences between the nonrandomized groups. Several limitations should nevertheless be acknowledged. First, the controlled quasi-experimental design limits causal inference compared with randomized allocation and cannot completely eliminate residual confounding or selection bias. Second, blinding of participants and intervention nurses was not feasible, creating potential expectancy and performance effects. Third, spiritual care and aromatherapy were delivered as a combined intervention, making it impossible to determine the independent

contribution of each component. Fourth, physiological outcomes were limited to routine clinical parameters; more direct mechanistic measures such as HRV, cortisol, and inflammatory biomarkers were not evaluated. Fifth, the single-center design and relatively modest sample size may limit generalizability. Finally, standardization of *P. amaryllifolius* aromatherapy remains an emerging area, and variability in extraction method, volatile composition, and administered dose may influence reproducibility.

4.9. Future Research

Future studies should evaluate this intervention using larger multicenter randomized controlled trials. A three-arm design comparing standard care, nurse-led spiritual care alone, and spiritual care plus *P. amaryllifolius* aromatherapy would clarify the incremental contribution of aromatherapy. A 2 × 2 factorial design would provide an even stronger test of the independent and interaction effects of spiritual care and aromatherapy. Mechanistic outcomes should also be incorporated. HRV may clarify autonomic regulation, salivary cortisol could reflect neuroendocrine stress responses, and CRP, IL-6, or related inflammatory markers could help evaluate psychoneuroimmunological pathways. Longer follow-up should determine whether early improvements in QoR-15 translate into clinically meaningful outcomes such as shorter ICU stay, reduced hospital length of stay, fewer readmissions, and better functional recovery.

Future research should also prioritize chemical characterization and dose standardization of *P. amaryllifolius* preparations to improve reproducibility and to clarify whether any observed effects are attributable to specific volatile constituents, broader olfactory mechanisms, or the integrative therapeutic context.

CONCLUSION

This controlled quasi-experimental study demonstrated that a nurse-led integrative intervention combining structured spiritual care with *Pandanus amaryllifolius* aromatherapy was associated with lower preoperative psychophysiological stress and better postoperative quality of recovery among patients undergoing elective cardiac surgery. Compared with standard perioperative care, patients receiving the intervention showed greater reductions in preoperative anxiety, heart rate, blood pressure, mean arterial pressure, and respiratory rate, together with higher postoperative QoR-15 scores. The greatest recovery benefits were observed in physical comfort, emotional state, and psychological support.

These findings suggest that integrating culturally responsive spiritual care with a plant-derived sensory intervention may provide a feasible and holistic adjunct to routine perioperative cardiovascular nursing. The intervention should be viewed as complementary to, rather than a replacement for, established medical, anesthetic, analgesic, and postoperative care. Given the nonrandomized design, single-center setting, modest sample size, inability to blind participants and intervention nurses, and the combined nature of the intervention, the findings should be interpreted cautiously. Larger multicenter randomized controlled trials are warranted to confirm effectiveness, determine the independent contribution of spiritual care and *P. amaryllifolius* aromatherapy, and evaluate longer-term clinical and patient-reported recovery outcomes.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the conception and design of the study, development of the nurse-led integrative intervention, participant recruitment, data collection, data analysis, interpretation of the findings, and preparation of the manuscript. All authors contributed to drafting or critically revising the manuscript, approved the final version for publication, and agreed to be accountable for all aspects of the work, including the accuracy and integrity of the study.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICS STATEMENT

Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sriwijaya, Indonesia, under approval certificate No. 421-2026. The study was conducted in accordance with applicable ethical principles for research involving human participants. Written informed consent was obtained from all participants before enrolment. Participation was voluntary, and participants were informed of their right to withdraw at any time without affecting the care they received.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are not publicly available because they contain participant-level information and are subject to confidentiality, institutional, and ethical restrictions. De-identified data may be made available by the corresponding author upon reasonable request and subject to approval by the relevant institutional and ethics authorities.

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