The effects of guided imagery on sleep and inflammatory response in cardiac surgery: a pilot randomized controlled trial

J. M. Casida [1], K. L. Yaremchuk [2],L. Shpakoff [3], A. Marrocco [4],G. Babicz [4], H. Yarandi [3]

[1]University of Michigam School of Nursing
Ann Arbor, MI, USA
[2]Head and Neck Surgery/Otolaryngology
Henry Ford Hospital
Ann Arbor, MI, USA
[3]Wayne State University College of Nursing
Detroit, MI, USA
[4]Cardiothoracic Surgery Department
Detroit, MI USA

Cardiac surgery is accompanied by sleep disturbance and systemic inflammatory response. Features of sleep pattern disturbances include an increase in sleep onset latency (SOL), and a decrease in total sleep time (TST) along with a poor sleep quality (SQ). Consequently, the patients' daytime function is compromised due to excessive daytime sleepiness, fatigue, and irritability resulting in lack of motivation to participate in post-operative care activities. Typically, longer recovery times and hospital care dissatisfaction ensue.[1-4] The systemic inflammatory response, a phenomenon commonly seen following cardiac surgery is typically manifested by high levels of stress hormones and inflammatory markers such as cortisol and c-reactive proteins (C-RP).[5-8] This clinical phenomenon is more evident in patients who undergo a cardiopulmonary bypass machine (ie, on-pump) than those who do not. Undergoing cardiopulmonary bypass procedure is a known risk factor, and predictor for, post-operative morbidity and mortality in cardiac surgery.[5-9]

The increase in SOL and decrease TST, a typical feature of the sleep pattern of a patient with insomnia, have shown to exaggerate stress and inflammation.[10] To minimize these problems, we proposed to int*e.g.*rate the use of a guided imagery program in the post-operative care of cardiac surgery patients. Guided imagery or guided visualization is a set of meditation and relaxation techniques used to direct the patient's attention away from unpleasant stimuli (*e.g.*, pain) to a positive and tranquil state leading the patient's progression into natural sleep.[11]The pain and anxiety-reducing effects of guided imagery enable the patient to enter into a relaxed state in preparation for sleep. Within this state, the brain naturally progresses through alpha and delta brainwave stages leading to the most conducive condition of mind and body for deep, natural sleep.[11-14]

The goal of this preliminary investigation was to lay the groundwork to test the applicability of using guided imagery as a sleep-promoting intervention immediately following cardiac surgery. Specifically, this study aimed to: 1) evaluate the feasibility and acceptability of int*e.g.*rating the guided imagery program in order to promote sleep and reduce the inflammatory response following cardiac surgery; and 2) identify and describe the differences in sleep patterns (SOL and TST), SQ, stress (cortisol) and inflammatory (C-RP) levels of patients who have used the guided imagery program compared to those patients who did not use the program at post-operative days (POD) 1 through 4.

Materials and methods

Institutional Review Board approvals were obtained prior to the implementation of the study. A pre-test/post-test, repeated measures control group design was employed. Patients who were scheduled

Corresponding author: J. M. Casida, PhD, APN-C, The University of Michigan School of Nursing, 400 North Ingalls, Room 2174, Ann Arbor, MI USA 48109. E-mail: jcasida@umich.edu

TABLE I.—*Inclusion and exclusion criteria.*

Inclusion	Exclusion
Adult male or female ages 18 years or older	Sleep disorders with or without treatment
Scheduled for first time elective cardiac surgery (ON-PUMP CABG/Valve)	Use of any one of these: Hypnosis, biofeedback, guided imagery as sleep aids in the past 6 months
Able to read and write with or without corrective lenses	Nightly use of sleep medications within 1 months of enrollment
Able to hear sounds and voices with or without hearing aid	Daily use of analgesics (narcotic or non-narcotic), anxiolytics, and/or anti-depressants within 1 month of enrollment
Able to understand written and verbal instructions in English	Uncontrolled migraine headaches
Consent to participate in the study	Presence of at least one of the following behavioral disorders: psychosis, paranoia, or related disorders such as manic-depressive psychosis

for elective "on-pump" cardiac surgical procedure at a large urban tertiary hospital in Southeast Michigan were screened for study eligibility using the criteria outlined in Table 1. Of the 215 patients screened, 52 provided an informed consent, and were subsequently randomized into either experimental (usual care + guided imagery [N.=27]) or control (usual care only [N.=25]) groups. Randomization was accomplished by selecting a sealed envelope in a box containing a code for group assignment. A study flow chart is illustrated in Figure 1.

Patients in the experimental group were taught about the study purpose and the steps involved in using a guided imagery program. They were given ample time to familiarize themselves with the intervention by using the program for at least 2 to 3 con-

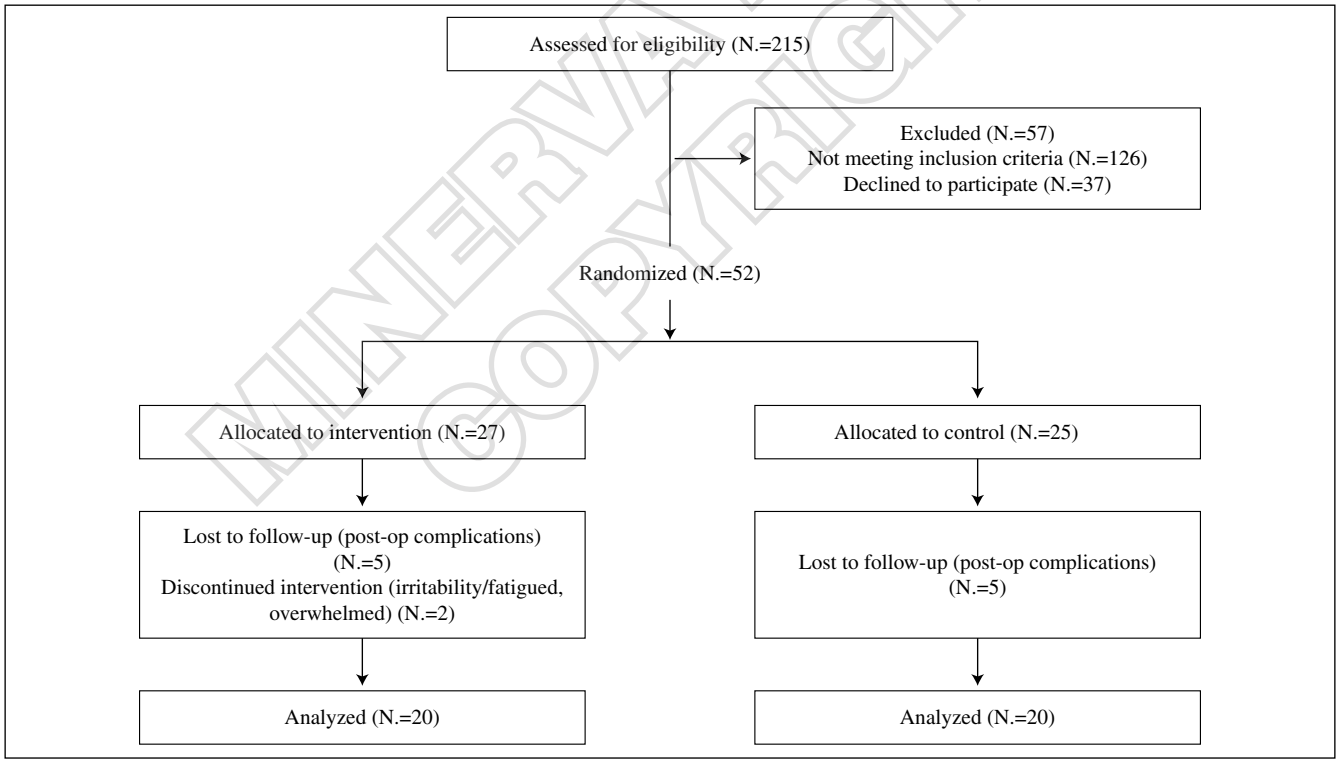

Figure 1.—Study flow chart.

secutive nights pre-operatively. Patients were asked to record the frequency and outcome of practice sessions on a one-page diary which they brought to the hospital together with the guided imagery program on POD 1. Also, the night staff nurses in cardiac surgical patient care units were educated about the intervention and their roles in the study.

Intervention

The guided imagery program selected for this study is entitled *Healthful Sleep*,[15] a widely known commercially-prepared program for self-management of insomnia. Patients in the experimental group were given an intervention package consisting of an MP3 player loaded with Healthful Sleep,[15] SleepPhones® (a fleece headband with built-in speaker phone worn over both ears)[16] and spare batteries. The intervention was administered by the nurse between 22:00 and 24:00 hours, with lights off and door closed. Study patients were provided with a minimum of one full-hour to listen to the program every night and every time their sleep was interrupted at night during POD1 to 4. For ease of access, the intervention package was kept on the patient's bedside table during the night in the ICU and step-down units.

Measures

Feasibility and acceptability

The feasibility of the intervention was evaluated with the proportion of the number of patients who completed the study and the number of patients who self-withdrew, as well as the nurses' compliance with the protocol. The patients' acceptability of the intervention was measured with a survey instrument, developed by the principal investigator, which uses a 7-item Likert response scale (1 = strongly disagree to 5 = strongly agree) evaluating their overall perceptions and satisfaction with the intervention. Patients were also asked to respond to 2 yes/no response items related to the int*e.g.*ration of a guided imagery program in routine postoperative care.

Sleep Patterns and SQ

For the purposes of this study, sleep patterns were operationalized with SOL and TST. SOL refers to the time it takes for a person to fall asleep (<15 minutes for normal sleepers) while TST refers to the total durations of nocturnal sleep which varies in lengths across the life span. SOL and TST were measured with wrist actigraph (Actiwatch 64W, Bend, OR),[17-19]a type of an accelerometer worn by patients on their non-dominant hand during a specified measurement time period. A wrist actigraph automatically calculates and analyzes movement data that are subsequently converted into sleep variables by accompanying computer software. Sleep patterns measured by wrist actigraph have shown high correlations (r=0.79 to r=0.98) with measurements of sleep using polysomnogram in normal and abnormal sleepers.[20] The patients' perceptions of their SQ were measured with 3 items of the Visual Analog Sleep Scales (VASS) which asks the patients' about sleep durations, awakenings after sleep onset, and restorative sleep. Patients were asked to draw a vertical line on a 100 mm horizontal straight line for each item situated between polar opposite ends. The ends of each line defined the extreme limits of response to be measured (*e.g.*, "awoke exhausted" at the left anchor and "awoke refreshed" at the right anchor). The VASS has shown sufficient validity with a reliability coefficient of α=0.93 in studies involving hospitalized and community-dwelling adults. The possible mean sum scores for 3 items ranges from 0 to 100 with higher scores indicating better SQ.[21, 22]

Stress and inflammation

Salivary cortisol and C-RP were selected as measures of overall inflammatory response. Cortisol and C-RP are commonly used indicators for evaluating biologic responses to acute injury and surgical stress. Positive high correlations between salivary and serum cortisol levels have been reported in many publications across age groups with various illnesses and/or clinical conditions.[23, 24] Correlations between salivary and serum C-RP values have not yet been established; however, a growing number of animal and human studies indicates positive relationships.[25] Sensitivity and specificity of salivary cortisol and C-RP measures have been established with enzyme-linked immunosorbent assays (ELISA). Normal ranges for the biomarkers employed in this study were 0.094 to 1.551 μg/dL (cortisol) and 1800.76 ± 2181.35 pg/mL(C-RP).[23, 26]

Data collection

SOL and TST were measured during 22:00 to 08:00 hours, and SQ was measured following morning awakenings within one month prior to surgery (T0) and during the intervention period (T1-T4). Salivary cortisol and C-RP levels were obtained between 06:00 and 08:00 hours during this period using Salimetrics® salivary oral swabs (State Coll*e.g.*e, PA) placed in the anterior sublingual area for two minutes.[27] Next, saliva specimens were kept in plastic tube containers and stored in a -57.0 °C freezer within 30 minutes of saliva collection. A guided imagery utilization log was completed by the staff nurses to capture the patients' compliance with the study protocol. The patients' perception and satisfaction of the guided imagery questionnaire was administered the following day after the intervention has been completed (POD 5).

Pertinent demographics and clinical characteristics were collected through interviews and reviews of medical records. Additionally, we collected pain intensity, anxiety levels, and medications to examine the extent of their influences on the outcome variables. In this study, we used a valid and reliable pain and anxiety assessment tool with 0 to 10 response scale (0 = absence of pain or anxiety to 10 = worst pain or anxiety)[28,29] administered every evening from T0 to T4. At the conclusion of the study, 40 (77%) of the 52 patients recruited to participate provided a complete data. The 23% attrition was mainly due to complications common following cardiac surgery shown in Figure 1.

Data analyses

Self-report questionnaires and wrist actigraph data were examined for completeness and scored accordingly. Frozen salivary cortisol and C-RP specimens were thawed at room temperature, then analyzed using ELISA kits (Salimetrics®, State Coll*e.g.*e, PA).[23,27] Descriptive statistical procedures were used to calculate means, standard deviations, and frequency distributions for the demographic, clinical, and outcome variables. Independent *t*-tests and chi-square statistics were used to determine the differences in demographic and clinical variables between groups. Mixed method repeated measures ANOVA (R-MANOVA) were used to detect time and group effects on each outcome variable. We used eta squared (η^2) to estimate the magnitude of effects between groups. Finally, ANCOVA procedures were employed to determine the extent of influence the select covariates (*e.g.*, gender) had on the outcome variables. All measures were tested at $P<0.05$ (two-tailed) level of significance using IBM SPSS 19.0 (Armonk, NY) and SAS 9.2 (Cary, NC) statistics software.[30, 31]

Results

Patients' characteristics

Table II presents a summary of the pertinent demographics, clinical profiles, and the baseline values of the main study outcome variables. We found a significant difference in gender composition, post-operative use of medications, and anxiety levels between groups. Patients in the experimental group were mostly females (55% *vs.* 20%) while patients in the control group were mostly males (80% *vs.* 45%); $X^2=5.76$, $p = 0.048$. While the number of patients who received beta-blocking agents was significantly higher in the control group (100%) than in the experimental group (70%); $X^2=7.06$, $p =.008$; more patients in the experimental group received some type of vasoactive agents than the patients in the control group throughout the intervention time periods (85% *vs.* 50%; $X^2=5.58$, $P=0.018$). Likewise, the mean anxiety score of patients in the experimental group was significantly lower (.98) than the controls (2.4); $t=-2.69$, $P=0.012$ (Table II).

Although patients in the experimental group appeared to be older, ethnically diverse, and had more CABG + valve procedures with longer intra-operative time than the patients in the control group, the mean and frequency distributions of these variables were not significantly different (P values >0.05). By and large, the socio-demographics, pre-operative co-morbidities, types of surgical procedures, intra-operative course, and other clinical variables (*e.g.*, pain and medications) in both groups were relatively equal. Furthermore, the study patients' sleep patterns and quality as well as inflammatory response were not significantly different at baseline (Table II).

Feasibility and acceptability of guided imagery utilization

All patients included in the data analyses have completed the pre-operative practice sessions with

TABLE II.—*Study patients' characteristics.*

Features	Experimental Group (N.=20) N. (%)*	Control Group (N.=20) N. (%)*	P values+
Age (mean in years)	62.8±14.2	58.5±17.0	0.319
Gender:			
Male	9 (45)	16 (80)	**0.048**
Female	11 (55)	4 (20)	
Marital Status:			
Single	1 (5)	4 (20)	0.249
Married	13 (65)	14 (70)	
Domestic Partner	1 (5)	1 (5)	
Widowed	4 (20)	1 (5)	
Ethnicity:			
African-American	7 (35)	5 (25)	0.229
Asian	2 (10)	0	
Caucasian	11 (55)	15 (75)	
Education:			
High School	3 (15)	7 (35)	0.127
Some College	3 (15)	4 (20)	
Baccalaureate degree or higher	8 (40)	2 (10)	
Employment Status:			
Employed	6 (30)	7 (35)	0.779
Unemployed/Retired	10 (50)	10 (50)	
Social History:			
Tobacco smoking	7 (35)	8 (40)	0.938
Alcohol consumption	6 (30)	7 (35)	0.425
Medical History:			
Coronary Artery Disease	12 (60)	15 (75)	0.744
Heart Failure/Valvular Disease	7 (35)	6 (30)	0.173
Diabetes	14 (17)	13 (65)	0.091
Hypercholesterolemia	5 (25)	10 (50)	0.527
Pulmonary Disease	3 (15)	3 (15)	0.311
Other	6 (30)	7 (35)	0.736
Surgical History:			
Yes	9 (45)	11 (55)	0.433
No	11 (55)	9 (45)	
Surgical Procedure:			
Coronary artery bypass graft (CABG)	9 (45)	12 (60)	0.592
Valvular repair or replacement	1 (5)	2 (10)	
CABG + valvular repair or replacement	10 (50)	6 (30)	
Anesthesia Time (mean in min)	382.1±99.2	327.9±96.8	0.504
Cross-clamp Time (mean in min)	117.0±76.5	102.4±53.6	0.500
Medications:			
Anxiolytics	1 (5)	3 (15)	0.292
Beta-blockers	14 (70)	20 (100)	**0.008**
Inotropic agents	3 (15)	2 (10)	0.633
Narcotic analgesics	17 (85)	20 (100)	0.072
Non-Narcotic analgesics	10 (50)	10 (50)	10.00
Sleep medications	0	1 (5)	0.311
Vasoactive agents	17 (85)	10 (50)	**0.018**
Anxiety Level (mean)	.98±1.0	2.4±2.1	**0.012**
Pain Intensity (mean)	2.4±1.6	3.3±1.7	0.105
Baseline Mean Scores:			
SOL (min)	8.9±6.9	11.6±15.8	0.508
TST (min)	256.7±105.6	215.93±74.0	0.176
SQ (mm)	60.4±12.6	56.2±13.0	0.321
Cortisol (μg/mL)	1.2±1.1	1.7±1.8	0.274
C-RP (pg/mL)	1742.3±2294.5	2458.2±4760.0	0.554

*Because of rounding or missing data not all percentages total 100; +based on independent *t* test and chi-square statistical analyses;±(standard deviation)
SOL: sleep onset latency; TST: total sleep time; SQ: sleep quality; C-RP: C-reactive protein

a mean of 2.6±1.85 nights. Nurses' and patients' compliance rate with the study protocol implementation were from 85% at T1 to 100% at T2 to T4, with mean frequency of guided imagery use of 1.68±1.1 times per intervention night. Common issues associated with <100% compliance at T1 included patients remaining sedated and failure of the family member to return the MP3 player. Additionally, the patients' perceptions of the quality of the guided imagery program and its components such as audio quality, ease of equipment use, and familiarity with MP3 players and SleepPhones® are critical factors in refining the methods for the next study and determining adherence and successful inte*.g.*ration of this guided imagery program into post-operative care. In general, patients reported high agreement with the items related to benefits and satisfaction with the guided imagery as a sleep-promoting intervention, as shown by mean scores of > 4.0 on the majority of the items illustrated in Table III.

Main study outcomes

Trends of sleep patterns and quality, and inflammatory response

Figures 2, 3 depict a snapshot of the trends in the changes of the patients' SOL, TST, SQ, cortisol, and C-RP levels across the study time periods (T1 to T4). Significant changes in the mean SOL, TST, and SQ were observed in both groups from T1 to T4 with P values <0.05 (Figures 2A-C). Changes in the mean cortisol levels across the study time periods were also significant (P=0.03), however, no significant changes in the mean C-RP levels was found (P=0.16) (Figures 3A, B).

Differences in sleep patterns and quality, and inflammatory response

Table IV summarizes the results of two-way R-MANOVA procedures showing no significant differ-

Table III.—*Patients perceptions and satisfaction of the guided imagery program (N.=20).*

Items	Mean (±SD)
The guided imagery program helped me….	
Slept well in the hospital	4.1 (1.1)
Get back to sleep when my sleep got interrupted at night	4.0 (0.9)
Relaxed every night	4.3 (0.6)
The guided imagery program help lower my pain levels at night	4.0 (0.9)
The program/equipment was easy to use	4.5 (0.9)
Satisfied with sound quality	5.0 (0.5)
Satisfied with the program as component of post-operative care	4.4 (0.6)

Table IV.—*Between groups R-MANOVA summary of sleep patterns, sleep quality, and inflammatory response.*

	Mean scores and standard deviations (±)								F	p	η^2
	T1		T2		T3		T4				
	Exp	Cont	Exp	Cont	Exp	Cont	Exp	Cont			
Sleep Onset Latency (min)	0.95 (1.0)	2.8 (7.3)	5.6 (19.7)	21.9 (86.2)	2.2 (6.0)	10.0 (29.3)	1.0 (20.0)	3.8 (42.5)	0.47	0.75	0.10
Total Sleep Time (min)	128.4 (51.0)	163.1 (88.4)	172.1 (190.0)	157.5 (71.1)	116.4 (67.8)	170.3 (77.7)	128.2 (45.6)	154.3 (60.1)	1.75	0.14	0.04
Sleep Quality (mm)	53.0 (14.6)	48.5 (16.0)	55.0 (14.6)	50.1 (14.0)	52.4 (14.5)	54.3 (14.4)	57.4 (19.0)	47.8 (14.4)	1.69	0.19	0.11
Cortisol (μg/mL)	0.83 (.64)	1.4 (1.5)	0.63 (.81)	1.6 (4.1)	0.54 (.65)	0.61 (.90)	0.25 (.16)	0.56 (.64)	0.46	0.76	0.03
C-Reactive Protein (pg/mL)	3039.0 (2756.7)	3174.9 (3797.7)	2694.4 (2395.6)	3211.2 (3111.2)	3191.4 (2105.2)	3490.6 (4330.1)	1799.5 (2424.4)	1839.8 (2035.7)	0.17	0.06	0.05

Exp: experimental group (N.=20); Cont: control group (N.=20).

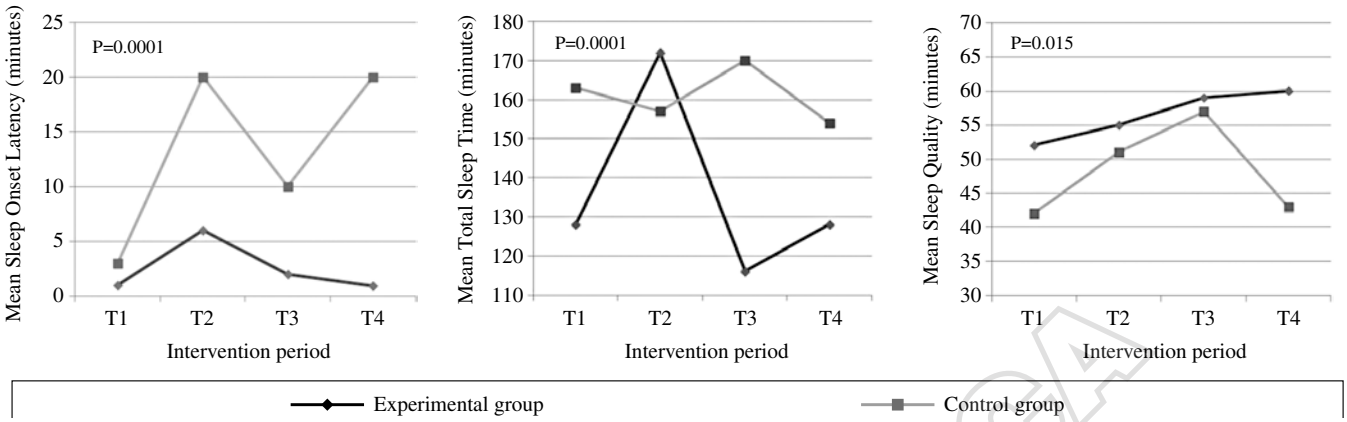

Figure 2.—A-C) Changes in the patients' sleep patterns and sleep quality over time.

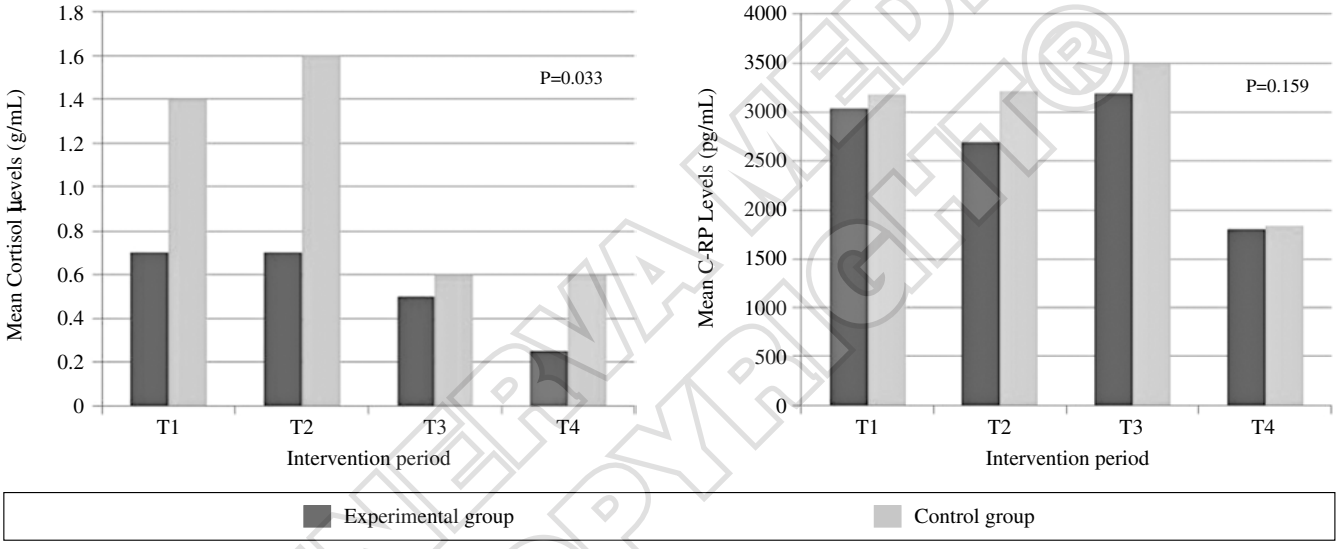

Figure 3.—Changes in the patients' inflammatory response over time.

ences in the mean SOL, TST, SQ, cortisol, and C-RP scores between patients in the experimental and control groups from T1 through T4. However, patients in the experimental group exhibited a steady improvement in SOL and SQ over the study time periods. The patients in this group had consistently demonstrated shorter SOL durations (0.95 to 5.6 min) than patients in the control group (2.8 to 21.9 min). Along this trend, they had better SQ than the controls, showing higher mean scores ranging from 52.4 to 57.4 mm (experimental) versus the control group ranges of 47.8 to 54.3 mm in the visual analogue scales. With the exception of T2, patients in the control group demonstrated relatively longer TST durations than the experimental group. The mean TST scores between groups at T1, T3 and T4 were ranged from 154.3 to 170.3 min (controls) and 116.4 to 128.4 (experimental) (Table IV).

Also, there were no significant differences in the salivary cortisol and C-RP levels of patients in the experimental and control groups were found (P values >0.05). However, it is worth noting that there were consistent decline in the cortisol and C-RP levels in patients in the experimental group than the

controls (Table IV). The mean salivary cortisol levels found in patients in the experimental group were ranged from 0.25 to 0.83 μg/mL compared to the 0.56 to 1.6 μg/mL range found in the control group. In addition, mean salivary C-RP levels of patients in the experimental group ranged from 1799.5 to 3191.4 pg/mL compared to the C-RP levels found in the control group, which ranged from 1839.8 to 3490.6 pg/mL (Table IV).

Discussion

Improvement in the patients' sleep outcomes along with a significant reduction in stress levels over time is a trend consistent with the pathophysiologic changes expected to occur beyond 72 hours postcardiopulmonary bypass. [32] Our data show that whether the patients used the guided imagery or not, their sleep tended to be shorter in duration and poorer in quality consistent to what have been reported in healthy populations and in patients who did not undergo a cardiac surgical procedure.[33-35]Despite controlling for the effects of gender, anxiety, and sleep-disrupting medications (*e.g.*, beta-blockers and vasoactive agents),[36] we did not find any significant differences in outcomes between groups. Yet, two key findings in our results merit attention and further investigations: 1) the positive trends in the sleep patterns and quality; and 2) consistent decline in inflammatory response seen during the study periods, particularly in patients who had used guided imagery.

Positive trends in sleep patterns

As shown in Figure 2A, patients in the experimental group had shorter SOL than the comparative group. Although the difference was not significant, it is important to note that a SOL of <6 minutes indicates higher propensity to falling asleep while using guided imagery as opposed to non-users. While there is an existing debate about the limitations of sleep time measured by wrist actigraph in critically-ill patients,[34] the shorter SOL can be explained by the concomitant effects of lower pain and anxiety levels when a patient is engaged with guided imagery program; a sleep-promoting mechanisms of guided imagery.[11] Within this state, the patient's mind and body is facilitated into a tranquil state, thus naturally progressing to deep sleep. The lower levels of post-operative pain and anxiety reported by guided imagery users in the present study (Table II) corroborate with the findings of a recently published systematic review.[37] The review consisted of seven studies that evaluated the efficacy of a guided imagery program in adult cardiac surgery in which pain and anxiety were measured as main outcomes. Within the seven studies, investigators employed a wide-range of doses and frequent use of a guided imagery program ranging from 18 to 60 minutes daily to "several times" a day. Despite the variations, program users showed consistent reduction in pain and anxiety throughout the post-operative period compared to non-users who received "usual care" or placebo (*e.g.*, white noise). Through synthesis of qualitative data, the authors concluded that the patients' high propensity to falling asleep is a by-product of the lower or absent pain and anxiety reported by the 397 patients who used a guided imagery program in these studies.[37]

Although the difference was not significant, we did not anticipate our finding that patients in the experimental group will have lower TST durations at T1, T3 and T4 than the controls (Table IV). A possible explanation of this finding include the environmental factors that are known to cause sleep disturbances among hospitalized patients (*e.g.*, noise, lighting practices, and care delivery processes).[35] In this context, one may infer that the patient's sleep continuity cannot be maintained alone by using a guided imagery program in spite of short SOL durations. Given the present study findings, a commercially-prepared guided imagery program should be used as a complementary therapy rather than an alternative for pharmacologic agents that are routinely used for promoting sleep following cardiac surgery. Furthermore, clustering interventions and providing patients with "down-time," when clinical stability permits, outside the sleeping hours (*e.g.*, early evening) may be necessary to rule out variables that interrupt sleep continuity when a patient is engaged with guided imagery.

Another surprising yet notable finding is divergence in the SQ and TST mean scores between groups, at T1 and T4 (Table IV). Ideally, mean TST scores are directly proportional to SQ scores (*i.e.*, higher SQ is accompanied by higher TST). The disparate trends between subjective and objective measures of sleep variables at T1 and T4, however, were

not an unusual finding, due to the inherent limitations of self-report and wrist actigraph. Studies have shown that occasionally these measurement tools may overestimate or underestimate the sleep variable of interest, particularly in regard to sleep durations among acutely/critically-ill patients.[34]Nevertheless, rather than dwell on this divergence and limitations of the measures employed, a more critical focus is the feature of this data set showing consistent positive trends in the perceived SQ outcomes among guided imagery users. This finding is clinically important as 95% (N.=19) of the first-time users of a guided imagery program had favorable views about its therapeutic effects and were highly satisfied with the int*e.g.*ration of the program in postoperative care (Table III). These perceptions were further substantiated by the patients' overall evaluation of the intervention in which all of them commented that they would consider using the program upon hospital discharge and would recommend it to a friend or a relative who is anticipating for cardiac surgery or any condition warranting hospitalizations.

Consistent decline in inflammatory response

The level of significance between the experimental and control group C-RP values was at P=0.058, a notable finding that may lead to P<0.05 when a larger sample is employed. In the present sample, the lower and consistent decline in salivary cortisol and C-RP levels manifested by patients who used the guided imagery program when compared to the controls is a positive indication that may support the stress and inflammation-reducing effects of the program Unfortunately, no data exists to compare and contrast this finding as the present study is the first to empirically evaluate the effects of guided imagery on inflammatory response following cardiac surgery.

Through extensive literature search, we found that in this area of inquiry the majority of investigators have employed interleukins and tumor necrotizing factor as measures of stress and inflammation, respectively. In spite of the diversity in measurements and (to some extent) the inconsistent results, there is a recurrent theme that guided imagery seems to reduce stress and inflammation in the non-cardiac surgical patient population.[36] Within the several publications we reviewed, only three studies have reported cortisol and C-RP as outcome measures for evaluating the effects of guided imagery/relaxation techniques.[38-40] In a quasi-experimental study involving 93 adults who had joint replacement surgery, the author found that cortisol level was significantly decreased among patients who used audiotaped relaxation techniques during POD 1 to 3 when compared to patients who received the usual postoperative care (484.4 *vs.* 618.8 mmol/L, P<0.02).[38] Out-of-hospital use of a guided imagery program in patients with chronic pain (N.=25) did not show statistically significant changes in the cortisol levels over the course of a 12-week intervention period.[39] Likewise, participants in an 8-week pilot study on a mindfulness-based stress reduction technique (ie, mind-body medicine) that was implemented in an academic center showed no significant change in the C-RP levels pre and post-intervention. However, a significant correlation between C-RP and anxiety (r=0.64, P<0.05) was found. Low levels of anxiety accounted for 20% of the variance for predicting lower C-RP levels following the intervention (P<0.02).[40]

Limitations

Ideally, a polysomnogram which remains, to this date, a gold standard measurement of sleep should be employed.[18] However, its utilization in the ICU and acute care areas in the hospital are impractical due to the associated high cost, requirement for a trained technician, and difficult use in busy patient care units. Thus, the sleep data in the present study are to be interpreted within the context of the realm of wrist actigraph and self-report measures of sleep. Aside from the small sample size and lack of understanding on the influence of care delivery processes (*e.g.*, around the clock administration of medications vital sign monitoring, etc), less rigorous implementation of the treatment fidelity were major limitations of the present study. Treatment fidelity, although not often reported or addressed in research studies, is a potential threat to statistical power validity. Treatment fidelity consists of five components of design (for accurate testing of the study's clinical process), training (of those researchers providing the intervention), delivery (to monitor the intervention accuracy), receipt (to ensure that the patient is able to perform the intervention), and enactment (the ability to perform the intervention in real life settings).[41] Issues that may have contributed to the lack of rigor with treatment fidelity in the present study include the reliance on a monitoring log reported by pa-

tients and nurses regarding the delivery, receipt, and enactment of the interventions. Having designated personnel to monitor and protect the integrity of treatment fidelity in the present study and/or future studies would be ideal.

Future directions

Clearly, the science that underpins the therapeutic effects of guided imagery on sleep, stress and inflammation is still evolving. Our data inches up the growing knowledge, particularly our efforts to link the effect of guided imagery sleep with stress and inflammation. This effort is timely as many sleep researchers are b*e.g.*inning to examine the relationships between sleep disruptions and inflammatory process. For example, van Leeuwen and colleagues[10] have reported their initial findings illustrating the direct relationships between sleep deprivation (ie, disturbance) and elevation of cortisol and C-RP levels. Thus, our data set the groundwork for advancing this area of science in the cardiac surgery patient population.

Longitudinal research, beyond the immediate post-operative period (*e.g.*, several months post hospitalization) and adequately powered sample size with equal representation of each type of surgical procedure (*e.g.*, CABG, valve, CABG + valve) are needed. Rigorous implementation of treatment fidelity and attention to issues with confounding variables is paramount to achieving definitive conclusions on the causality of guided imagery on sleep and inflammatory response. As hemodynamic and clinical stability permits, investigators should consider developing strat*e.g.*ies to manipulate the care delivery processes such as clustering the administrations of routine, non-emergent tests, procedures, and/or medications around the waking hours (early evenings or late mornings). Other environmental factors that may potentiate the effects of guided imagery on sleep continuity include the practice of dimming lights and reducing ambient noise including equipment alarms and staff conversations proximal to the patient care areas.[35] It is also worth noting that inclusion of an attention-control group (*e.g.*, use of "white noise") in future studies can be beneficial in discriminating the true intervention outcomes from placebo effects [39] which could provide a more concrete explanation of the divergence in the SQ and TST found in the present study.

Conclusions

This is the first study that empirically evaluated the effects of a commercially-prepared guided imagery program on sleep and inflammatory response following cardiac surgery. The study findings suggest that the use of guided imagery alone may not be sufficient in sustaining sleep continuity and reducing the stress and inflammation in adult post-operative cardiac surgery patients. However, a guided imagery program can be successfully int*e.g.*rated as a complementary therapy in the night time routine management of patients recovering from cardiac surgery. Despite the study limitations, patients' positive perceptions on the therapeutic benefits and satisfaction with the program may have some influence on their psychological well-being and result in improved patient satisfaction. Large scale and methodologically rigorous studies are warranted to establish conclusive evidence explicating the causal effects of guided imagery on sleep and inflammatory response. This preliminary data inches up the science that underpins the utilization of non-pharmacologic modalities, such as guided imagery, as sleep-promoting interventions for hospitalized patients which is aligned with the importance of implementing high quality, patient-centered care.

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