# Physiological, Psychological and Autonomic Responses to Pre-Operative Instructions for Patients Undergoing Cardiac Surgery

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## Abstract

**Several studies have reported that the experience may induce emotional reactions before and after surgery. Various Studies have demonstrated that effective pre-operative information reduces stress and anxiety levels. However, little is known about the effect of pre-operative instruction on autonomic responses as measured by heart rate variability (HRV) before cardiac surgery. Ninety-one patients were randomly assigned to video-tape viewing and teaching booklet group. Electrocardiogram was monitored before and after pre-operative instruction. HRV was analyzed with spectral analysis of frequency domains of heart rate and categorized into low and high frequency (LF and HF). After pre-operative instruction, subjects completed a score of perceived stress and helpfulness. In this study, we found that pre-operative instruction with video-tape was similarly effective as teaching booklets on patients' perceived stress, perceived helpfulness and recovery outcomes. The decrease in HF% and increase in LF/HF ratio of HRV indicate a change in sympathovagal balance toward a lower parasympathetic activity after pre-operative instruction in subjects of both groups. However, the perceived helpfulness of pre-operative instruction may often be associated with a relatively less sympathetic activity. Further studies are needed to determine the optimal timing to enhance the positive effects on the sympathovagal balance after pre-operative instruction.**

**Key Words: pre-operative instruction, cardiac surgery, heart rate variability, perceived stress, perceived helpfulness**

## Introduction

Coronary artery bypass graft (CABG) surgery is a common and successful procedure for coronary revascularization. However, the pre-operative experience may induce emotional reactions. Anxiety and stress are caused by fear, lack of knowledge about the oncoming situation and possible outcomes. Thus, the pre-operative instruction is particularly important for cardiac patients who will require ventilation on an intensive care unit after surgery and may have to undergo a number of invasive procedures (23).

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Wishine *et al*. (32) conducted a study to determine the importance of specific information in pre-operative instruction for patients undergoing open heart surgery. Data were collected from 19 patients after surgery over a period of 9 weeks. Their results indicated that patients agreed all information received was useful.

Hathaway (10) carried out meta-analysis of 68 cases and proposed that patients who received pre-operative education had better post-operative outcomes than those who did not receive such instruction. Lindeman (16) also suggested that pre-operative teaching is an effective intervention that promotes recovery from surgery. More investigations are required to develop methods of pre-operative teaching using new technologies such as computer-assisted instruction, home video, audio recordings, cable television and others. With the short length of hospital stay and the limited time for teaching, media can be very helpful adjuncts for the relief of anxiety and stress.

Pre-operative educational intervention program now is an essential component of hospital care. Mahler and Kulik (18) conducted a large scale survey in a total of 258 male patients preparing for coronary artery bypass graft. The subjects were randomly assigned to two groups. One group received video-tape viewing on the evening before surgery, while the other group did not receive any pre-operative instruction. The study suggested that patients who viewed video-tape felt significantly better prepared in the recovery period, reported higher self-efficiency for using the incentive spirometer and for speeding their recovery, had shorter intensive care unit stay, and were released from the hospital more quickly than patients without video-tape viewing. Asilioglu and Celik (3) had assessed the effect of pre-operative education on anxiety of open cardiac surgery patients. The patient in the intervention group had lower anxiety scores than the patients in the control group. However, there was no statistically significant difference in the state and trait anxiety scores between the groups. Almost all patients in the intervention group agreed that education booklet was helpful to reduce the pre-operative anxiety.

Stress is usually defined as the experience of distress and adverse effects that are associated with the inability to cope with them (37). Studies have demonstrated that effective information for open heart patients reduces stress, anxiety (13), but also some studies did not find statistically significant effects of education on anxiety levels of cardiac surgery patients (3, 20).

Psychophysiological responses, related to autonomic nervous system arousal of cardiac patients, were studied as indicators for anxiety. Heart rate, incidence of arrhythmias, blood pressure and state anxiety were measured. The results provided evidence that sensory vulnerability was the most consistent predictor for arousal, and that previous caregiving experiences that were perceived as "negative" by the patient also contributed to increases in blood pressure and anxiety (31).

Alterations in HRV have been reported in people with clinical anxiety disorders (7). In several reports, patients with generalized anxiety disorder had a lower HF component of HRV during a resting baseline and during worry, indicating reduced vagal modulation of cardiac function, as compared with a non-anxious control group (30, 35). Yeragani *et al*. (35) reported lower LF components among patients with panic disorder compared with controls. On the contrary, Rechlin *et al*. (26) found a higher VLF (very low frequency) component, suggesting an elevated sympathetic modulation of HRV in panic disorder patients compared with controls who were matched in age and gender. Dishman *et al*. (6) recently addressed the relationship between self-rating anxiety or emotional stress and the parasympathetic component of HRV among physically fit men and women. Their results suggested that the relationship was independent of personality and cardiorespiratory fitness. They also disclosed an inverse relationship between perceived stress and the normalized high frequent component of HRV. The relationship was independent of age, gender and trait anxiety. Furthermore, stress or anxiety tended to reduce the cardiac vagal tone in men and women.

Previous studies have demonstrated that effect of pre-operative information on stress and anxiety levels as measured by self-rating or subjective anxiety inventory (12, 20, 23, 25). Since mental stress is difficult to measure, the change in autonomic nervous function may be useful for the evaluation of patient's response to stress (34, 35). In this regard, the analysis of heart rate variability (HRV) may be a useful tool.

Teaching booklet for pre-operative instructions was often utilized in our cardiovascular intensive care unit (CVSICU) for patients preparing for cardiac surgery. Currently, we developed a teaching method with video-tape for patients undergoing cardiac surgery. In this study, we assessed whether a video-tape viewing could be as effective as teaching booklet, and examined the relationship of HRV, perceived stress and perceived helpfulness in patients preparing for cardiac surgery.

## Materials and Methods

### *Participants*

The subjects were consisted of 91 adult patients preparing for CABG for the first time. Criteria for selection were: Mandarin or Taiwanese speaking, patients over 18 years of age waiting for cardiac surgery without any known history of psychiatric or brain

diseases. Informed consent was obtained from all subjects. Patients were randomized into video-tape viewing group (n = 41, aged 67.4 ± 13.9 years) or into teaching booklet group (n = 50, aged 67.7 ± 12.3 years).

*Demographic and Outcome Measures*

Demographic data were collected on all patients included age, sex, education level. The outcome measures of the study were: total time of instruction (minute), time to tracheal extubation (day), duration of stay in CVSICU, frequency of using incentive spirometer in CVSICU.

*Definition of Outcome Measures*

Total time of instruction (minute) was defined as the average duration of instruction and discussion. Time to tracheal extubation (day) was defined time from ICU admission to endotracheal extubation. Duration of stay in CVSICU (day) was defined to be the time from ICU admission to transfer to ward. Frequency of using incentive spirometer in CVSICU was recorded with the numbers of using incentive spirometer after endotracheal extubation. The scale of perceived stress was an item with a three-point rating scale (1 to 3). Higher scales indicated that patients' perception of nursing instructions was more stressful. This scale of perceived stress was similar to a visual analogue scale of perceived stress (28). The scale of perceived helpfulness was assessed with a three-point rating scale (1 to 3). Higher scales indicated that patients' perception of pre-operative instructions was more helpful. We validated the rating scales before the study by interviewing ten patients after instruction. We focused on whether patients' responses were consistent, whether patients could understand the questions. Three nurses trained in interview techniques participated in all rating scales, during the validation process and with study patients.

*Heart Rate Variability*

Power spectral analysis (PSA) of heart rate variability (HRV) has been applied for more than thirty years (13). It has been used for the evaluation of autonomic nervous functions following sympathetic and/or parasympathetic blockade, the role of renin-angiotension system and posture changes (1, 30). Because of its sophistication, non-invasiveness and accessibility, PSA of HRV has gained popularity with broad application as a functional indicator of the autonomic nervous system (ANS). PSA of HRV is categorized into high-frequency (HF, 0.15-0.40 Hz) and low-frequency (LF, 0.04-0.15 Hz) components (14, 29, 33). The HF component is related to the respiratory sinus arrhythmia (RSA) and vagal activities to the heart (4). LF component is jointly contributed by neural activities of both vagal and sympathetic nervous systems (4). The normalized total power (TP) from 0.04 to 0.15 Hz was used to quantify LF HRV, while the TP from 0.15 to 0.40 Hz was used to quantify HF HRV. The LF/HF ratio reflects sympathovagal balance (2, 22) or sympathetic modulation (19, 22, 24, 33). LF was normalized as the percentage of total power excluding the very low frequency (VLF) component (total power - VLF) as LF% to detect the sympathetic influence on HRV. A similar procedure was also applied to HF%.

*Processing of ECG Signals*

The computer program for HRV analysis was modified from previous methods (14, 29, 33). In the QRS identification procedures, the computer first detected all peaks of the digitized ECG signals by a spike detection algorithm (14) similar to the general QRS detection algorithms. Then parameters such as amplitude and duration of all spikes were measured so that their means and standard deviations (SD) could be calculated as standard QRS templates. Each QRS complex was thus identified, and each ventricular premature complex or noise was rejected according to its likelihood in standard QRS templates. The R point of each valid QRS complex was defined as the time point of each heart beat, and the reverse of R-R internal was measured as heart rate (HR).

*Frequency-Domain Analysis of HRV*

We employed frequency-domain analysis of HRV. Detailed procedures of frequency-domain analysis with fast Fourier transform were described previously (14, 29, 33). The direct current component was deleted, and a Hamming window was used to attenuate the leakage effect. For each time segment (288 s, 2048 data points), the algorithm estimated the power spectral density on the basis of fast Fourier transform. The resulting power spectrum was corrected for attenuation resulting from the sampling and the Hamming window. The power spectrum was subsequently quantified into various frequency-domain measurements.

*Intervention*

Both intervention groups who received an instruction were blind to the actual purpose of the study. Methods of pre-operative instructions were a video-tape and a booklet. The materials were simple language at a reading level of primary school. Each item was associated with graphics to reinforce understanding. Both teaching program instructed

**Table 1. Demographic data of participants**

| Characteristics | Video-tape ($n$ = 41) | | Booklet ($n$ = 50) | | $P$ |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Age | | | | | |
| < 50 | 2 | 5 | 5 | 10 | 0.63 |
| 50-59 | 5 | 12.5 | 7 | 14 | |
| 60-69 | 9 | 22.5 | 11 | 22 | |
| 70-79 | 24 | 58.5 | 23 | 22 | |
| > 80 | 1 | 2.5 | 4 | 8 | |
| Sex | | | | | |
| Male | 29 | 70.7 | 38 | 76 | 0.15 |
| Female | 12 | 22.3 | 12 | 24 | |
| Levels of education | | | | | |
| Illiteracy | 4 | 9.8 | 4 | 8 | 0.87 |
| Literacy | 4 | 9.8 | 5 | 10 | |
| Elementary school | 20 | 48.8 | 20 | 40 | |
| Junior high school | 6 | 14.6 | 11 | 22 | |
| Senior high school | 7 | 17.1 | 10 | 20 | |

patient with surgical equipments and procedures including cardiac monitor, arterial line, pulmonary artery catheter, endotracheal tube, ventilator, suctioning, endotracheal tube removal, urinary catheter, restraint, method of pain relief, routine of care, the need for coughing, deep breathing exercise, training of incentive spirometer, progressive exercise, infection control, and family visiting time. In the teaching booklet group, researcher used the booklet to educate the patients. In video-tape viewing group, the patients were given the educational video-tape. Each instruction was followed by an explanation and demonstration of respiratory exercises, leg exercises, pain management and early ambulation by researcher. The session was concluded by reinforcement of information and answering of questions.

*Data Collection*

Pre-operative education was delivered on the evening before surgery. First, subjects were asked to sit down in a quiet room for at least 10 min. Then, electrocardiogram was recorded for 5 min. Immediately after the teaching program, another electrocardiogram was recorded. The scale of perceived stress and perceived helpfulness given after instruction were rated. The study period was approximately one year.

*Statistical Analysis*

Values are expressed as means ± standard error of means (S.E.M.). Difference between the video-tape viewing and teaching booklet groups on the demographic, outcome data and HRV were analyzed by Student's *t*-test. Differential HRV effects on nursing instruction with video-tape viewing and teaching booklet groups were compared before and after instruction using Paired t test. Pearson's correlation analysis was used to evaluate the relationship between HRV, perceived helpfulness of pre-operative instruction and individual perceived stress. A $P$ value < 0.05 was considered to be statistically significant.

## Results

*Demographic and Outcome Data*

The age, sex, levels of education were not significantly different between the two study groups (Table 1). Table 2 summarizes the outcome data between groups. The total time of instruction with video-tape viewing was significantly shorter than that in teaching booklet group ($t$ = 10.1, $P$ < 0.001). The mean scale of perceived stress was 1.3 ± 0.1 and 1.3 ± 0.1 on a total scale of 3 in the video-tape viewing and teaching book group, respectively ($t$ = -0.18, $P$ = 0.87). In patients perceived scale of helpfulness of instruction, the mean scale was 2.8 ± 0.1 and 2.9 ± 0.1 on a total scale of 3 in the video-tape viewing and teaching booklet group, respectively ($t$ = 0.90, $P$ = 0.17). There were no significant differences in scale of perceived stress, scale of perceived helpfulness, time to tracheal extubation, duration of CVSICU stay, and frequency of using incentive spirometer between the two groups.

**Table 2. Comparison of outcome data between groups**

| Outcomes | Video-tape ($n$ = 4) | Booklet ($n$ = 50) | $P$ |
|---|---|---|---|
| Total time of instruction (min) | 16.1 ± 0.8 | 28.9 ± 1.3 | < 0.001 |
| Scale of perceived stress | 1.3 ± 0.1 | 1.3 ± 0.1 | 0.86 |
| Scale of perceived helpfulness of nursing instruction | 2.8 ± 0.1 | 2.9 ± 0.1 | 0.17 |
| Time to tracheal extubation (day) | 1.1 ± 0.2 | 1.3 ± 0.3 | 0.63 |
| Duration of CVSICU stay (day) | 4.8 ± 1.2 | 4.2 ± 0.6 | 0.61 |
| Frequency of using incentive spirometer in CVSICU | 1.8 ± 0.2 | 1.7 ± 0.2 | 0.07 |

Values are means ± S.E.M. CVSICU, Cardiovascular intensive care unit.

**Table 3. Heart rate variability before and after instruction in the video-tape and teaching booklet groups**

| Component | Video-tape ($n$ = 41) | | Booklet ($n$ = 50) | |
|---|---|---|---|---|
| HRV | Before | After | Before | After |
| HR | 72.1 ± 2.1 | 72.8 ± 2.0 | 75.8 ± 2.2 | 75.9 ± 2.2 |
| LF | 4.6 ± 0.3 | 4.7 ± 0.3 | 4.4 ± 0.3 | 4.4 ± 0.3 |
| VLF | 5.7 ± 0.2 | 6.1 ± 0.3 | 5.3 ± 0.2 | 5.5 ± 2.2 |
| HF | 4.2 ± 0.3 | 3.9 ± 0.3 | 4.2 ± 0.3 | 3.9 ± 0.3 |
| LF/HF | 0.4 ± 0.1 | 0.7 ± 1.3* | 0.2 ± 0.2 | 0.6 ± 0.1$^{\dagger}$ |
| LF % | 45.3 ± 3.1 | 50.5 ± 2.8* | 41.7 ± 2.9 | 47.4 ± 2.8 |
| HF % | 30.5 ± 2.0 | 25.9 ± 1.9* | 33.4 ± 2.3 | 28.7 ± 2.0$^{\dagger}$ |
| TP | 6.4 ± 0.3 | 6.6 ± 1.7 | 6.2 ± 0.2 | 6.3 ± 1.6 |

Values are means ± S.E.M. HR, heart rate; VLF, very low frequency; LF, low frequency; HF, high frequency; LF/HF, index of cardiac sympathetic activity; LF %, normalized values of low-frequency power; HF %, normalized values of high-frequency power; TP, total power.
*$P$ < 0.05, comparison between the values before and after instruction with video-tape viewing. $^{\dagger}P$ < 0.01, comparison between the values before and after teaching booklet.

*Change in Heart Rate Variability following Instruction*

The HRs were not significantly altered after either video-tape viewing or teaching booklet. However, the variability of heart rate presented various levels of change (Table 3). LF% significantly increased in the video-tape viewing group ($t$ = -2.05, $P$ < 0.05), but not in the teaching booklet group. HF% significantly decreased after instruction in both groups ($t$ = -2.18, $P$ < .05; $t$ = 2.89, $P$ < 0.01). LF/HF ratio also significantly increased after instruction in both groups ($t$ = 2.19, $P$ < 0.05; $t$ = -2.9, $P$ < 0.01). Men had greater LF% and LF/HF ratio than women. On the other hand, HF% in women was greater than that in men (Fig. 1). It appeared that men were more nervous than women.

*Analysis of the Psychological Responses to Pre-Operative Instructions*

In 91 subjects following pre-operative instruction, 23.9% ($n$ = 16) of men and 37.5% ($n$ = 9) of women perceived stress. Perceived stress scale was not significantly different between gender (men: 1.3 ± 0.6 *vs.* women: 1.4 ± 0.60, $P$ > 0.05). Pearson's correlation analysis indicated that perceived stress scale was significantly and inversely associated with the perceived helpfulness of instruction ($r$ = -0.48, $P$ < 0.001).

Pearson's correlation analysis disclosed that perceived stress scale was not significantly associated with HRV component. The perceived helpfulness of nursing instruction was inversely associated with VLF ($r$ = -0.21, $P$ < 0.05) (Table 4).

## Discussion

Previous investigations have shown the benefits of pre-operative information to patients. The most positive results in these studies were seen in recovery of the patient undergoing surgery (9, 10, 12, 18). However, there were also some studies revealed no statistically significant effect of the education on anxiety levels of open cardiac surgery patients (3, 20, 23). In our study, the effects of pre-operative information were not different in scale of perceived stress, scale of perceived helpfulness of instruction, time to tracheal extubation, duration of CVSICU stay and frequency of using incentive spirometer in CVSICU between two groups. The finding indicated that video-tape

**Table 4. Pearson correlation coefficients between perceived stress and helpfulness of pre-operative instruction and HRV parameter**

| | VLF | LF | HF | LF/HF | LF % | HF % |
|---|---|---|---|---|---|---|
| Stress | 0.15 | 0.09 | 0.10 | -0.03 | -0.00 | 0.03 |
| Helpfulness | -0.21* | -0.05 | 0.00 | -0.10 | -0.08 | 0.10 |

HRV, heart rate variability; VLF, very low frequency; LF, low frequency; HF, high frequency; LF/HF, index of cardiac sympathetic activity; LF %, normalized values of low-frequency power; HF %, normalized values of high-frequency power. *$P < 0.05$.

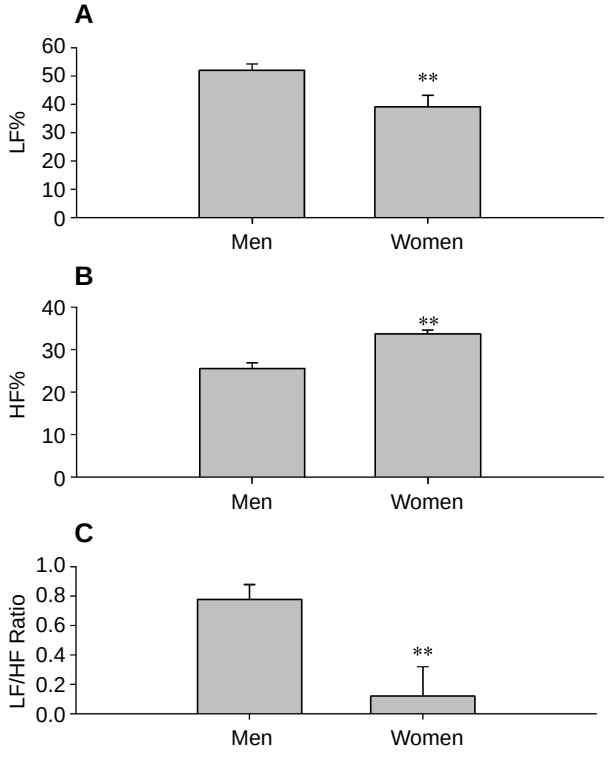


Fig. 1. The normalized values of low-frequency power (LF %, A), high-frequency power (HF %, B) and LF/HF ratio (C) after instruction in men and women. The values are expressed as means ± S.E.M. ($n = 70$ in men group and $n = 21$ in women group). **$P < 0.01$, significantly different between men and women.

and booklets provided equally effective pre-operative instructions. In the present study, total time of instruction in the video-tape viewing group saved 12 minutes. However, LF% increased significantly to reflect enhancement of sympathetic activity after instruction in video-tape subjects before cardiac surgeries. Accordingly, we suggest that video-tape viewing was the potential time saving of pre-operative information program, but it is important to note that pre-operative instruction should reinforce an individual discussion with the patient and the family (27).

Several authors reported that anxiety or stress is associated with sympathetic nervous activity (8, 21, 36). Data collected in our current study indicated that HF% decreased and LF/HF ratio increased significantly, reflecting a lower parasympathetic activity after instruction in both groups. In our study, subjects who were scheduled for coronary artery bypass were admitted one day prior to surgery, the time available for education before surgery was limited to the evening which would be the most anxious time for patients (11). Pre-operative education delivered on the evening before surgery may be helpful in preparing patients to cope with post operation experience (5, 15). However, HRV data in our study indicated that sympathetic predominance in response to instruction in the both groups. There remains a need for further study to identify the optimal timing for a maximum positive effects on patients sympathovagal balance after instruction.

It has been reported that previous caregiving experiences that were perceived as negative by the patient also contributed to increased blood pressure and anxiety (31). In our study, subjects also claimed that pre-operative instructions were useful (mean scale of 2.8 and 2.9 on a total scale of 3). There was an inverse relationship between perceived helpfulness after instruction and the VLF of HRV. The result indicated a less sympathetic component of HRV among subjects who perceived usefulness for their recovery by pre-operative instructions. This result supported the significance of pre-operation teaching which contribute to meet patients' information needs would help in lowering anxiety level (12). In the present study, men had greater sympathetic reaction and less parasympathetic activity than women after instructions. Madden and Savard (17) investigated the effects of mental state on HRV in men and women. The results also showed that the sympathetic indicator of HRV was lower in women during control and mental stress tests. Further studies are needed to determine why men have greater change in autonomic activities in response to mental stress. Nevertheless, the fact of the gender difference in physiologic responses to mental stress deserves attention in the preparation of patient for surgery.

We conclude that pre-operative instruction with video-tape was similarly effective as teaching booklets on patients' perceived stress, perceived helpfulness

and recovery outcomes. Although the data indicated that sympathetic predominance in response to instruction in subjects of both groups. However, the subjects perceived helpfulness of pre-operative instruction may often be associated with a relatively less sympathetic activity in the sympathovagal balance.

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