

Innovative Immersive Virtual Reality-DREAM Protocol in Post-operative CABG-ICU Patient: A Case Study.

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Abstract:

Background:

The risk of coronary artery disease (CAD) is three to five times higher in the South Asian population. Following CABG, 7% to 60% of patients reported having persistent postoperative intensive care syndrome (PICS) like pain, stress, anxiety, and sleep disturbances. These unrelieved postoperative symptoms will lead to long ICU stay and reduced quality of life (QOL). Immersive virtual reality is a real time interaction of a 360-degree virtual world through the principle of immersion, engagement, and distraction. So, VR in ICU acts as a complement to traditional treatment strategies.

Case Summary:

This is a case study of a post CABG patient who is 53-year-old male and complaints (%) of pain in the postoperative suture site which leads to anxiousness due to stay in the ICU. So, he was treated with VR and conventional therapy using dream protocol. The pre and post therapy pain was analyzed with numerical pain rating scale (NPRS) and anxiety state was analyzed with state trait anxiety inventory (STAI). Secondary outcomes like respiratory rate (RR), heart rate (HR), inspiratory effort were observed from POD 0 to POD 3 after that he was shifted to ward and from POD 0 to POD 6 shoulder range of motion (ROM) pre and post analysis was also done.

Results:

Pre- and post-assessment NPRS ratings differed by 8 to 1, while the STAI showed a difference of 58(High anxiety) to 27(low anxiety). There was a difference observed in the vitals, inspiratory effort, and shoulder ROM.

Conclusion:

IVR along with conventional physiotherapy reduces patient pain, anxiety and associated functional complications there by improving the functional status of the patient. Thus, IVR proved to be effective in treating Postoperative CABG patients.

Keywords:

Immersive Virtual reality (IVR), Intensive care unit (ICU), Post-CABG, Therapeutic game-based exercise

Introduction:

The risk of coronary artery disease (CAD) is three to five times higher in the South Asian population. In India, about 60,000 CABG surgical procedures are carried out annually. Following CABG 7% to 60 % of patients reported having persistent postoperative intensive care syndrome (PICS) like pain, stress, anxiety, and sleep disturbance. Among these symptoms usually pain and anxiety are unexplored gray areas as much importance is not given to the patients. The pain and anxiety are linked in a vicious cycle in which the pain leads to anxiety which changes the breathing pattern and delays the patient's recovery refer Fig1.

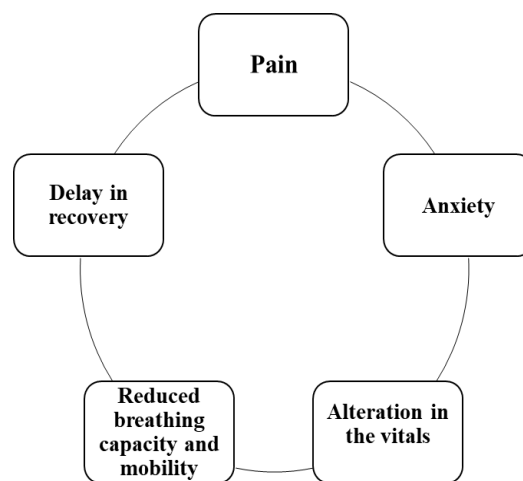


Fig 1

Pain is considered as an unavoidable problem involving 80% of patients undergoing surgeries. It may differ from patient to patient because it is a subjective and personal feeling(1). The perception of pain is influenced by many factors like surgical trauma, method of anesthesia, biological, psychological, and sociological factors(1). Post CABG, 49% of patients reported severe pain during rest, 78% reported during coughing, 62 % during movements and pain is also reported after movements, turning around, or getting up from bed and even in deep breathing

(2). The experience or the fear of pain may lead to shortness of breath, impaired expectoration of secretions, reduction in tidal volume, vital capacity, functional residual capacity, and pulmonary compliances(1). Anxiety refers to the feeling of nervousness, fear, apprehension and worrying. The symptoms are approximately observed in 40% of pre-operatively due to the awaiting for the surgery, fear of surgery as heart is considered as the central organ of the body(3). The prevalence of ICU anxiety is reported 12% to 47%. Post-operative anxiety may be due to ICU exposures like

pain, insertion of drains and chest tubes, noise of the monitors, post-surgical status. Anxiety disorders appear to be generalized anxiety disorder, panic disorder, phobias, post-traumatic stress disorders which is reported in 11%. Studies have reported that anxiety precipitates cardiac decompensation owing to higher autonomic arousal thus delaying healing and recovery(4). These unrelieved postoperative symptoms like pain and anxiety have a greater impact on the patient's recovery status especially in ICU, leading to prolonged ICU stay and reduced quality of life. Traditional conventional physiotherapy helps in addressing pain and anxiety. But the involvement of the patient is quite challenging with many discomforts. Immersive Virtual reality (IVR) is an advanced digital therapeutic technology with an enriched multi modal sensory environment that creates a sense of presence. IVR works through the principles of immersion, engagement, and distraction. So, this case study aims to reduce the post-operative pain and anxiety which enhances early recovery and mobilization in phase 1 CABG patient through the DREAM protocol.

Patient History:

The patient is a 53- year-old-male who was apparently normal, and on 02/09/2023, he developed pain in the left shoulder and upper back which was sudden in onset. After a few minutes he also developed profuse sweating and breathlessness and was taken to the nearby clinic and was advised for ECG. Following ECG abnormalities, he was taken to the “R” hospital and was planned for an angiogram and was diagnosed with large vessel disease. So, CABG was done on 03/09/2023. Post CABG patient was in ICU from POD-0 to POD-2 and complained of post-operative pain and anxiety. POD- 3 patients were shifted to ward and POD -6 patients were discharged.

Past Medical History:

Patient is a K/C/O,

- DM X 10 years on regular medications
- HTN X 5 years on regular medications

Surgical History:

- **Past Surgical History:** No History
- **Present Surgical History:** Coronary artery bypass surgery with saphenous grafting off pump procedure under general anesthesia on 03/09/23. Median sternotomy procedure.

Personal History:

- K/C/O Smoker x 30 years.
- Diet: Mixed Diet
- Sleep: Normal

Family History: Not relevant

Socio- economic status:

According to Modified Kuppuswamy Scale patient lies under lower middle class.

Investigations:

ECG: 02/09/23

ST elevation with anterior wall MI

Angiography: 02/09/23

Triple vessel disease with 85% of lesion in the left anterior descending artery, 80 % in left circumflex artery, 70 % in the mid right coronary artery and distal coronary artery.

Post surgery clinical findings:

Post surgery, the patient was observed and treated from POD-0.

General Examination:

- **Built:** Mesomorphic
- **BMI:** 22 kg/m²
- **HR:** 102 beats/ min
- **BP:** 130/90 mmHg
- **RR:** 24 breaths/ min

On Observation:

Ventilation Support:

Stage 1 – received from the theater	Stage 2 - ICU	Stage 3 – After extubating	Stage 4
Volume controlled ventilator	SIMV + PS Mode	O2 mask	Weaning off from O2 support

Posture: Rounded shoulder, Forward head posture.

Face: Very anxious look.

External Appliances:

- B/L Lower limb pneumatic compression stockings present
- Dressings present in the chest site.

Pattern of breathing:

Use of accessory muscles more than the diaphragm

Pain assessment:

Patient complaints of post operative pain and discomfort in the suture sites.

On Examination:

Pain Assessment:

NPRS: 8

Chest Symmetry: Symmetrical

Chest Expansion:

- **At Nipple Level:** ½ cm
- **At Axilla:** ½ cm
- **At Xiphisternum:** 0cm

On Auscultation:

B/L Air entry present with crepitus present in the left lower lobe than the right side

Inspiratory Effort: Volume based spirometer.

250 cc/sec

Cough Assessment:

Non-Productive cough

Drain Assessment:

- Central drain - 15ml
- Coastal drain - 100ml

Psychological Status:

Patient % anxiousness because of being in the ICU. So, a state trait anxiety inventory test was used to assess the anxiousness.

State Trait Anxiety Inventory: 58 -High Anxiety

Problem List:

- Pain in the postoperative suture site
- ICU anxiousness
- Reduced bronchial hygiene.
- Reduced inspiratory effort.
- Decreased functional ambulation.

Short term goal:

- To reduce the post operative pain
- To reduce ICU anxiousness
- To improve the bronchial hygiene
- To improve the inspiratory effort
- To improve the Upper Limb & Trunk Mobility
- To improve the sitting to standing, standing, and walking

Long term goal:

To enable the patient for phase III cardiac rehabilitation.

Physiotherapy Management:

The patient was treated twice a day with Physiotherapy. The first session included conventional cardiac rehabilitation (CCR) and the second session included IVR along with CCR refer table 1. The IVR with CCR was given to reduce pain and anxiousness which indirectly normalized the vitals like respiratory rate, heart rate and improved the inspiratory effort and even the shoulder ROM. The VR therapeutic games were given to patients in different positions like reclined position, sitting and standing with different VR settings through dream protocol, refer table 2.

D- Digital Multi-sensory enriched environment

R- Relaxation

E- Exercise/ Engagement

A- Attitude/ Attention

M- Motivation

Table: 1

Post Operative Day	CCR			IVR (Therapeutic VR game was given to the patients for 15-30 mins)
	Chest PT	Limb PT	Mobilization	
POD 0 ICU	<ul style="list-style-type: none"> ● Chest percussions ● Deep Breathing exercises ● Assisted Splinted cough and huff. ● Incentive spirometry 	<ul style="list-style-type: none"> ● Ankle Pump 	Nil	Relaxation therapy <ul style="list-style-type: none"> ● Calm ● Focus Temple
POD 1 ICU	<ul style="list-style-type: none"> ● Chest percussions ● Deep 	<ul style="list-style-type: none"> ● Ankle Pump ● Chin tuck ● Active 	<ul style="list-style-type: none"> ● Supine to side lying. ● 8Side Lying 	Relaxation therapy <ul style="list-style-type: none"> ● Calm ● Focus Forest

	<p>Breathing exercises</p> <ul style="list-style-type: none"> ● Assisted Splinted cough and huff. ● Segmental breathing exercises ● Incentive spirometry ● Paper blow exercises 	<p>assisted exercises to B/L shoulder</p> <ul style="list-style-type: none"> ● Active exercises to other UE's. ● Active exercises to B/L Lower limbs 	<p>to sitting.</p> <ul style="list-style-type: none"> ● Standing with supervision ● Frequent long sitting encouraged 	
POD 2 ICU	<ul style="list-style-type: none"> ● Chest percussions ● Deep Breathing exercises ● Splinted cough and huff ● Segmental breathing exercises ● Thoracic mobility exercises ● Incentive spirometry ● Paper blow exercises 	<ul style="list-style-type: none"> ● Ankle Pump ● Chin tuck ● Active assisted exercises to B/L shoulder ● Active exercises to other UE's. ● Active exercises to B/L Lower limbs ● Knee and hamstring isometrics ● Shoulder rotation. 	<ul style="list-style-type: none"> ● Supine to side lying. ● Side Lying to sitting. ● Standing with supervision ● Near Bed mobilization with minimal support ● Chair sitting for 20 mins 	<ul style="list-style-type: none"> ● Calm ● Penguin in sitting ● Focus Temple
POD 3 Ward	<ul style="list-style-type: none"> ● Deep Breathing exercises ● Splinted cough and 	<ul style="list-style-type: none"> ● Ankle Pump ● Chin tuck ● Active exercises to B/L UE and 	<ul style="list-style-type: none"> ● Supine to side lying. ● Side Lying to sitting. ● Standing 	<ul style="list-style-type: none"> ● Calm ● Penguin- sitting to standing. ● Fruit Catch in sitting. ● Save Jerry sitting. ● Focus Forest

	<ul style="list-style-type: none"> huff ● Segmental breathing exercises ● Thoracic mobility exercises ● Incentive spirometry ● Paper blow exercise 	<ul style="list-style-type: none"> LE ● Knee and hamstring isometrics ● Shoulder rotation. ● Manual resistance knee extension training 	<ul style="list-style-type: none"> with supervision ● Walking 2 rounds independently ● Chair sitting for 30 mins 	
POD 4 Ward	<ul style="list-style-type: none"> ● Deep Breathing exercises ● Splinted cough and huff ● Segmental breathing exercises ● Thoracic mobility exercises ● Incentive spirometry ● Paper blow exercise 	<ul style="list-style-type: none"> ● Ankle Pump ● Chin tuck ● Active exercises to B/L UE and LE ● Knee and hamstring isometrics ● Shoulder rotation. ● Manual resistance knee extension training 	<ul style="list-style-type: none"> ● Supine to side lying. ● Side Lying to sitting. ● Standing with supervision ● Walking 3 rounds independently ● Chair sitting for 45 mins 	<ul style="list-style-type: none"> ● Calm ● Mr. Punch in sitting. ● Fruit Catch in standing ● Save Jerry sitting. ● Focus Temple
POD 5 Ward	<ul style="list-style-type: none"> ● Deep Breathing exercises ● Splinted cough and huff ● Segmental breathing exercises ● Thoracic 	<ul style="list-style-type: none"> ● Ankle Pump ● Chin tuck ● Active exercises to B/L UE and LE ● Knee and hamstring isometrics 	<ul style="list-style-type: none"> ● Supine to side lying. ● Side Lying to sitting. ● Standing with supervision ● Walking 3 rounds independen 	<ul style="list-style-type: none"> ● Calm ● Penguin in sitting. ● Save Jerry sitting. ● Mr. Punch in standing ● Fruit Catch in standing ● Focus Temple

	mobility exercises ● Incentive spirometry ● Paper blow exercise	● Shoulder rotation. ● Manual resistance knee extension training	tly ● Chair sitting for 45 mins. ● Stair Climbing 4 steps	
POD 6 Discharge	● Deep Breathing exercises ● Splinted cough and huff ● Segmental breathing exercises ● Thoracic mobility exercises ● Incentive spirometry ● Paper blow exercise	● Ankle Pump ● Chin tuck ● Active exercises to B/L UE and LE ● Knee and hamstring isometrics ● Shoulder rotation. ● Manual resistance knee extension training	● Supine to side lying. ● Side Lying to sitting. ● Standing with supervision ● Walking 3 rounds independently ● Chair sitting for 45 mins. ● Stair Climbing 6-7 steps	● Calm ● Save Jerry sitting. ● Penguin in standing ● Mr. Punch in standing ● Fruit Catch in standing ● Focus Temple

Table 2

Therapeutic VR Game	Purpose	Settings	Game Procedure
Calm	● Facilitate proper breathing. ● Relaxation ● Reduce the shortness of breath.	Duration: 60-180 sec Inhale Time: 2-4 sec Hold Time: 1-5 sec. Exhale Time: 4-8 sec Rest time: 3-5 sec	The patient must follow the breathing cycle of breath in, hold, breath out, relax by the settings prefixed by the therapist.
Focus Temple and Forest	● Relaxation ● Reduces anxiety/	Nil	The patient task is to navigate inside the big

	stress and depression		Thanjavur temple or the forest
Penguin	<ul style="list-style-type: none"> ● Facilitate the static and dynamic trunk mobility in sitting and standing. ● Improves the shoulder range of motion. 	<ul style="list-style-type: none"> ● No of Penguins: ● Shoulder Flexion: 90-160 degree ● Horizontal Adduction: 10-45 degree ● Horizontal Abduction: 10-70 degree 	The patient must bend their trunk forward, grasp the penguin with their hand, and place it on a rock platform that is positioned in different directions.
Fruit Catch	<ul style="list-style-type: none"> ● Facilitate the static and dynamic trunk lateral flexors mobility in sitting and standing. ● Improves the shoulder range of motion. 	<ul style="list-style-type: none"> ● Total Throw count: 10- 25 ● Vertical Reach: 90-160 degree ● Horizontal Reach: 10-70 degree ● Delay Between the throw: 5-15 sec 	The patient task is to catch the fruits flying towards them by raising their hand
Boxing/ Mr. Punch	<ul style="list-style-type: none"> ● Facilitate the static and dynamic trunk mobility in sitting and standing. ● Enhances shoulder protraction and retraction. 	<ul style="list-style-type: none"> ● Duration: 60-180 sec ● Flexion: 20-120 degree ● Forward: 65-80cm ● Adduction: 20-45 degree 	The participant's task is to bend forward and punch the boxing pad.

Outcome measures:

Individual session outcome:

The RR refer table 3.1, HR refer table 3.2 and inspiratory effort refer table 3.3 was analyzed pre and post from POD 0 to POD 3

Table 3.1

Respiratory Rate (RR)	CCR 1st session		IVR therapy with CCR 2nd session	
	Pre	Post	Pre	Post
POD 0 Post extubating	24 bpm	28 bpm	21 bpm	16 bpm
POD 1	30 bpm	27 bpm	27 bpm	18 bpm
POD 2	25 bpm	22 bpm	25 bpm	14 bpm
POD 3	21 bpm	20 bpm	21 bpm	15 bpm

Table 3.2

Heart Rate (HR)	CCR 1st session		IVR therapy with CCR 2nd session	
	Pre	Post	Pre	Post
POD 0 Post extubating	102 bpm	100 bpm	107 bpm	98 bpm
POD 1	100 bpm	96 bpm	100 bpm	90 bpm
POD 2	90 bpm	86 bpm	88 bpm	82 bpm
POD 3	82 bpm	80 bpm	81 bpm	78 bpm

Table 3.3

Inspiratory Effort (Volume based spirometer) Started from POD 1	CCR 1st session		IVR therapy with CCR 2nd session	
	Pre	Post	Pre	Post
POD 1	250 cc/sec	Less than 500 cc/sec	250 cc/sec	500 cc/sec

POD 2	500 cc/sec	Less than 750 cc/sec	Less than 750 cc/sec	1000 cc/sec
POD 3	1000 cc/sec	1000 cc/sec	1000 cc/sec	1250 cc/sec

Cumulative outcome measures:

The pain and the anxiety level were measured as the primary outcome using the numerical pain rating scale (NPRS) and State trait anxiety inventory (STAI). In addition, the secondary outcome shoulder range of motion was also evaluated refer to table 4 and Fig 3.1, 3.2, 3.3. These were analyzed from POD 0 to POD 6.

Table 4

Outcome Measures	POD -0	POD-6
VAS	8	1
STAI	58 - High Anxiety	27- Low Anxiety
Shoulder Flexion	0- 60 degree	0- 130 degree

Fig 3.1

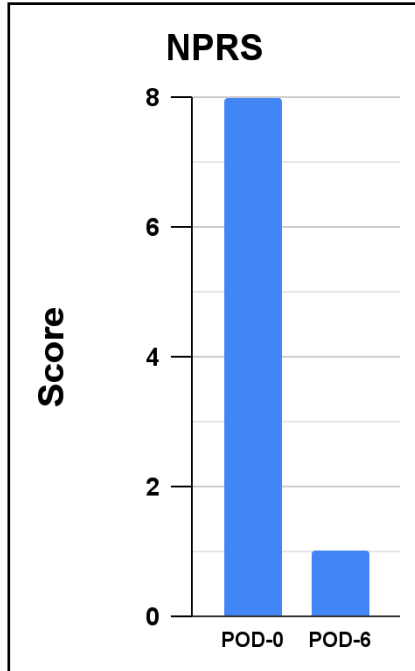


Fig 3.2

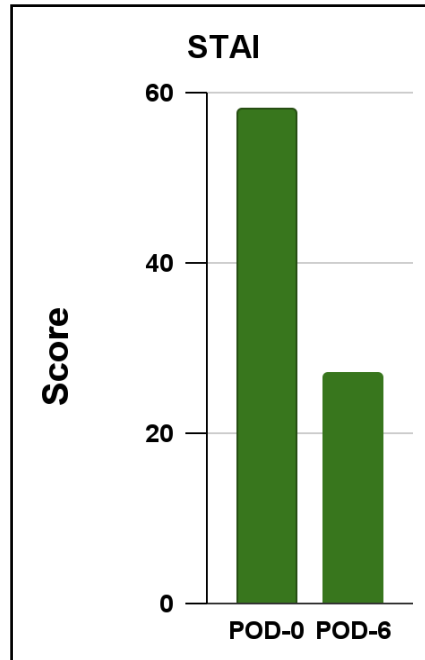
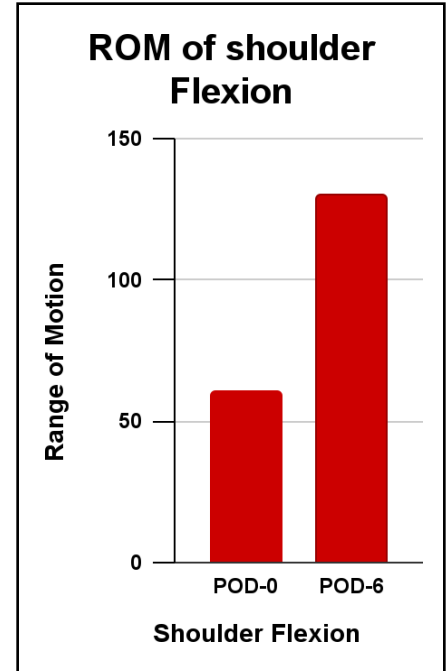


Fig 3.3



Discussion:

After cardiac surgery, it is common for patients to show symptoms like pain, anxiety, stress, and depression. Even though these are considered as psychological factors they may limit movements like bed mobility, walking and reduced bronchial hygiene. It is evident that Pain in postoperative CABG patients leads to anxiety which in turn reduces mobility so their breathing capacity changes which reduces the functional capacity of a patient. Studies have stated that VR is shown to improve post-surgical distress in ICU. In this case study, VR was given to the patient along with conventional Physiotherapy, to reduce the post-operative pain and anxiety. The DREAM VR protocol is utilized in this study which refers to D- Digital multi-sensory enriched environment, where the patient is immersed in the virtual environment, R- Relaxation therapy, E- active patient engagement through therapeutic game exercises, A- creates positive attitude and attention towards the exercises, M- finally the patient gets motivated with VR. A study has

reported that 90 % of patients' pain level decreased post-therapy with VR which was evaluated through Likert scale(5). Secondly, in this study we can observe that the post shoulder range of motion is also improved. Therefore, IVR even in ICUs represents an effective treatment along with conventional physiotherapy in reducing pain and anxiety through relaxation which in turn improves the mobility and the functional status and quality of life of post CABG patients.

Conclusions:

IVR along with conventional physiotherapy reduces patient pain, anxiety and associated functional complications there by improving the functional status of the patient. Thus, IVR proved to be effective in treating Postoperative CABG patients.

Way Forward:

VR is a potential and an efficient treatment along with conventional treatment in postoperative CABG patients. It therefore paves the way for future in all phases of cardiac rehabilitation and comparison study between conventional cardiac rehabilitation and immersive virtual reality with larger sample size especially in Indian populations for better patient benefits and outcomes can be done.

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