

Virtual Reality for Anxiety Reduction in Patients Undergoing Non-Surgical Cardiac Procedures: A Narrative Review

Réalité virtuelle pour la réduction de l'anxiété chez les patients subissant des interventions cardiaques non chirurgicales : Une revue narrative

Siwar Belhaj Salem¹, Sarah Suwal², Sahira Shrestha², Linh Huynh³, Sara S⁴, Syed Muhammad Hassan⁵, Jayashree Ravikumar⁶, Ariba Furqan⁷, Muhammad Ali Muzammil⁸

1. Department of Family Medicine, Faculty of Medicine of Monastir, Monastir, Tunisia.
2. Nepal Medical College and Teaching Hospital, Kathmandu, Nepal.
3. Kansas Health Science Center, Wichita, United States.
4. Department of internal medicine, A.R Hospital, Ramanathapuram, India.
5. Karachi Medical and Dental College, Karachi, Pakistan.
6. Department of Internal Medicine, Sri Varadhar Consultation Clinic, Chennai, India.
7. Department of Internal Medicine, Dow University of Health Sciences, Karachi, Pakistan.
8. Dow University of Health Sciences

ABSTRACT

Invasive cardiac procedures are a source of anxiety and discomfort for patients, often impacting their physical and mental wellbeing. While medications remain the standard care for anxiety management in these patients, numerous non-pharmacological alternatives like virtual reality have also been adopted to help manage the resulting distress. Virtual reality constitutes a novel technology that may help reduce the patients' periprocedural anxiety and pain by providing distraction and relaxation as well as education about the procedures. Thus, we aimed to investigate the effectiveness of virtual reality in anxiety management during non-surgical cardiac procedures, including coronary angiography, cardiac catheterisation, catheter ablation for cardiac arrhythmias, and transcatheter valve implantation. We conducted a narrative review using the PubMed database that included 17 studies. After an in-depth analysis of these studies, we concluded that virtual reality is an efficient tool for increasing patients' preoperative preparedness and education, lowering anxiety levels during the procedure and potentially reducing post-procedural stress. This review also highlights the limitations of the studies and future areas of research, illuminating the need for further studies and standard guidelines to address more profoundly the application of this technology in daily cardiac procedures.

Key words: Virtual reality; Anxiety; Cardiology; Cardiovascular disease; Cardiac catheterization; Angioplasty

RÉSUMÉ

Les interventions cardiaques invasives peuvent susciter une anxiété considérable et un inconfort chez les patients, impactant à la fois leur bien-être physique et mental. Bien que le traitement pharmacologique constitue la norme en matière de gestion de l'anxiété chez ces patients, diverses alternatives non médicamenteuses, parmi lesquelles la réalité virtuelle, ont été explorées pour atténuer la détresse associée à ces procédures. Cette technologie innovante offre un potentiel significatif pour réduire l'anxiété et la douleur qui précède ses interventions, tout en permettant une éducation des patients. Ainsi, nous avons mené une revue de la littérature visant à évaluer l'efficacité de la réalité virtuelle dans la gestion de l'anxiété lors des interventions cardiaques non chirurgicales, telles que le cathétérisme cardiaque, l'ablation par cathéter des troubles du rythme cardiaque, la coronarographie et l'implantation valvulaire percutanée. Il s'agit d'une revue narrative à partir de la base de données PubMed, incluant un total de 17 articles. Nous avons conclu que la réalité virtuelle constitue un outil précieux pour améliorer la préparation et l'éducation des patients avant les interventions, diminuer les niveaux d'anxiété durant la procédure, et potentiellement alléger le stress post-procédural. Cette étude souligne également les limites des travaux existants ainsi que les perspectives de recherche futures, mettant l'accent sur la nécessité de l'élaboration des approches standardisées afin d'approfondir l'implémentation de cette technologie dans les actes de cardiologie quotidiens.

Mots-clés: Réalité virtuelle; Anxiété; Cardiologie; Maladie cardiovasculaire; Cathétérisme cardiaque; Angioplastie

Correspondance

Siwar Belhaj Salem

Department of Family Medicine, Faculty of Medicine of Monastir, Monastir, Tunisia.

Email: siwarbelhajsalem@gmail.com

INTRODUCTION

Cardiac procedures are essential for addressing various cardiovascular conditions in order to ensure holistic patient care (1). These invasive cardiac procedures are associated with an enormous distress for patients. For instance, 87% of patients undergoing implantable cardioverter defibrillator (ICD) placement are prone to develop anxiety, with around 38% showing symptoms resembling those seen in an anxiety disorder (2). Anxiety is as well prevalent among patients who have experienced acute coronary syndrome (ACS), in which the effects may persist for up to a year and a half. These high levels of anxiety, linked to worse outcomes in coronary artery disease patients, manifest as a sensation of apprehension and activation of the autonomic nervous system in response to a vague menace. Furthermore, around 32% of heart failure patients report heightened anxiety levels (3,4). Managing anxiety and pain during medical procedures often involves the use of benzodiazepines and opioids, which can lead to numerous side effects such as respiratory depression, nausea, and extended recovery periods. In contrast, non-pharmacological approaches like hypnosis and virtual reality (VR) constitute safer alternatives (1,5). VR, a technological interface that allows users to experience computer-generated environments in a controlled setting, has shown promising outcomes in reducing anxiety and pain during various invasive procedures (6). This new technique is revolutionizing cardiac interventions through a comprehensive approach that aims to enhance patients' education and understanding, soothe peri-procedural anxiety, as well as facilitate rehabilitation and recovery afterward (7). Thus, the recent literature has shown its benefits in improving psychological outcomes in invasive procedures through distraction techniques (8). The aim of this study is to assess the application and effectiveness of virtual reality in managing anxiety, enhancing patients' education and supporting healthcare providers during non-surgical heart procedures.

METHODS

We conducted an electronic systematic literature search to the date of 13 October 2024 using the PubMed database. We have included the following search term into our Boolean search syntax: ((Virtual reality) AND (Anxiety) AND ((Cardiac procedures) OR (Cardiac catheterization) OR (Catheter Ablation) OR (Angioplasty) OR (Coronary angiogram) OR (Cardioversion))). As a first step, titles and abstracts were screened to identify relevant studies. Based on the predefined inclusion and exclusion criteria, full-text articles of the selected studies were retrieved and evaluated for eligibility. We included studies that focused on: 1) Adult patients (>18 years), 2) VR technology application for anxiety management and 3) Papers written in English language. Articles related to surgical cardiac procedures were excluded.

RESULTS

Initial database search yielded 195 records as illustrated in Figure 1, 17 studies met the inclusion criteria, nine of which were randomised clinical trials (RCT) and four were reviews. Four studies assessed the use of VR for anxiety management in different cardiac procedures, 10 papers focused on coronary angiography and catheterization and 3 studies focused on VR application in atrial fibrillation ablation (1,7–21).

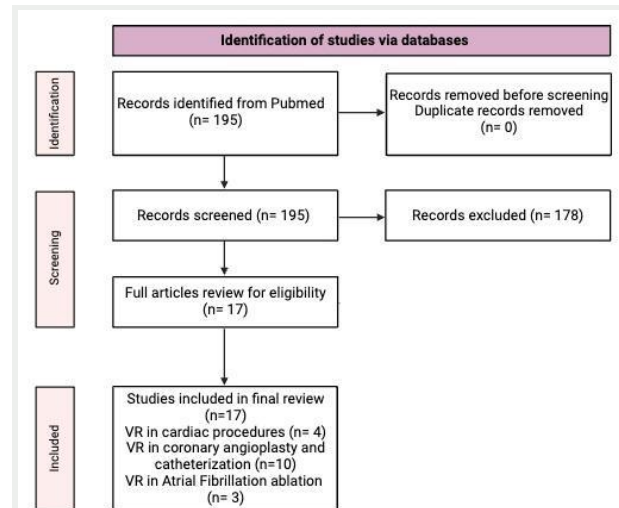


Figure 1. Flow chart for literature search and included studies

Figure 1 shows the flowchart of the study with a total of 17 included papers.

The characteristics of the included RCT were summarized in Table 1 including the cardiac procedures, the VR intervention type and characteristics, the primary outcome and the main results. Figure 2 illustrates the steps followed in RCT from data collection and analysis of the findings during VR interventions (8,9,11–13,15,18,19,21).

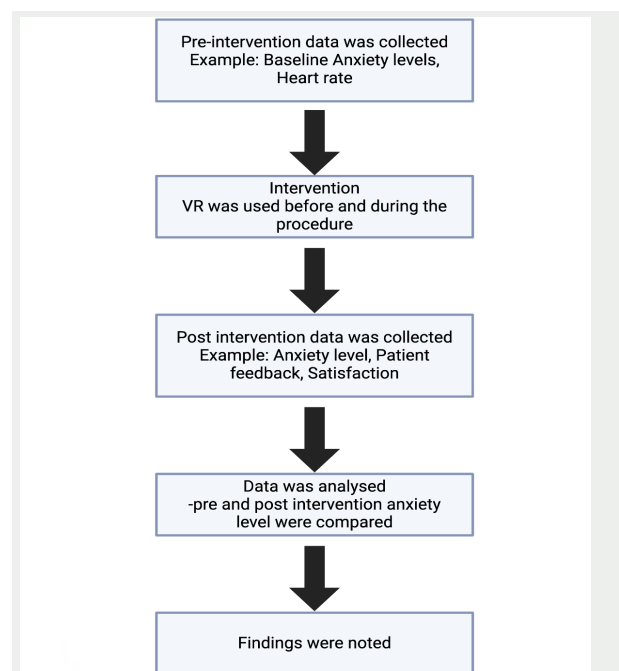


Figure 2. Data Collection and Analysis Workflow

Figure 2 illustrates the steps followed in RCT from data collection and analysis of the finding during VR interventions.

Table 1. Characteristics of included randomized clinical trials.

Study	Sample	Intervention	Comparison	Intervention characteristics	Primary outcome	Results
Chang SL et al. 2021 China	Catheter ablation of Atrial Fibrillation (AF) (n=33) Male (n=16) Female (n=17)	(n=11) Head-mounted display (HMD) VR	Paper group (n=22)	Periprocedural education via 3-minute interactive VR-based materials concerning the procedure from disinfection to catheter ablation.	Knowledge, self-efficacy, satisfaction, pain, anxiety, impatience, analgesia, procedure's duration and comfort (assessed by blinded operators)	Increased knowledge, self-efficacy, and satisfaction and decreased pain, anxiety, and impatience in the intervention group during the procedure.
Paalimäki-kki et al. 2023 Finland	Coronary computed Tomography Angiography (CCTA) (n=86)	(n=41) 360° VR	Standard care (n=45)	360° VR was opened 2 weeks before the CCTA and closed 6 months after	State- Trait Anxiety Inventory (STAI) CCTA process time	Significant reduction in pain, anxiety, stress, and blood pressure (BP) Women demonstrated higher anxiety at baseline than men Similar waiting and examination times
Bruno RR et al. 2020 Germany	Transcatheter aortic valve implantation (TAVI) (n=32) Males (62.5%) Median age=83 years	(n=16) MEDION® ERAZER® 3D VR glasses: Nature sceneries	Standard care (n=16)	The day before the procedure, VR materials were demonstrated to patients. Intervention duration and time the glasses have been worn by the patients were recorded.	Simple Visual Analogue Scale (VAS)	Significant lower anxiety levels before and during the procedure in the VR group (VAS 2 [IQR 0 - 3.75] vs 5 [IQR 2-8]; p= 0.04)
Morgan H et al. 2021 UK	cardiac catheterization (n= 64) Median age=68.7 years Male=27 (42%) Female=37 (58%)	(n=33) VR headset simulated environment of a typical day for a patient	Standard care (n=31)	Patients were familiarized with the virtual reality experience before the procedure and a 10-minute video containing details about the catheterization periprocedural aspects.	Mean anxiety score Pre-procedure and post-procedure anxiety scores Overall reduction in anxiety	Mean pre-procedural anxiety score (VR group = 11.9, control group = 13.1 p<0.05) Mean post-procedural anxiety score (VR group = 8.5 vs control group = 9.7 p<0.05) Higher mean understanding score for the rationale of catheterization in the intervention group (3.85/4 vs 3.48/4 p <0.05).
Turan GB el al. 2023 Turkey	Coronary angiography (n=70)	(n=35) Cardboard Super Flex Binoculars Glasses	Standard care (n=35)	One minute before the procedure until the end, the patients watched with an Android mobile phone the licensed procedure «Secret Garden» with a music background by VR for 30 to 45 minutes.	Visual analogue scale (VAS) Anxiety assessment scale Physiological symptoms of anxiety follow-up form -VR Glasses application satisfaction form	Significant reduction of anxiety scores in intervention group (I= 4.25 ± 1.80, C=7.14 ± 0.91; p<0.001) Decrease of patients' pain, Diastolic blood pressure (DBP), Systolic blood pressure (SBP), Heart rate (HR) and increase in oxygen saturation
Lind A et al. 2023 Germany	transfemoral TAVR (TFTAVR) (n=117) Male=59 (50.43%) Female=58 (49.57%)	(n=58) VR HappyMed system	Standard care (n=57)	The VR intervention commences at the beginning of the procedure.	post-interventional anxiety scores (STAI-S)	Lower STAI-S in the VR group (31.5 ± 13.4 vs 38.5 ± 19.2 p<0.05)
Gökçe E et al. 2023 Turkey	Coronary angiography (n=153)	(n=51) Oculus VR glasses (nature sceneries or open-air museum tours with nature sound effects and relaxing music	Standard care (n=51) Acupressure (n=51)	VR intervention was commenced 10 minutes before the femoral catheter extraction following the procedure and was pursued throughout the procedure (30 minutes)	Visual analogue scale (VAS) State-trait anxiety inventory (STAI) Perianesthesia comfort scale (PCS)	The mean pain and anxiety scores during and after the procedure were lower in the VR and acupressure groups compared to the control group with higher comfort scores (p<0.001) Lower SBP, Respiratory rate (RR), Pulse rate in VR and acupressure groups than control group (p<0.05)
Keshvari M et al. 2021 Iran	Coronary angiography (n=80)	(n=40) VR headset 360° degree nature scene	Standard care (n=40)	VR intervention was given before the angiography is started.	State-trait anxiety inventory (STAI) HR, SBP, DBP, RR	Lower STAI score in the intervention group Lower HR in the intervention group
Larsson CE et al. 2023 France	Coronary angiography (n=156)	(n=76) VR headsets (nature sceneries)	Usual care (n=80)	VR headsets were used 20 minutes before the procedure.	Preprocedural anxiety (SDNN) after 20 minutes of treatment Evaluation of anxiety by VASA	SDNN and VASA scores were not statistically different between the 2 groups.

Effectiveness of VR in the management of periprocedural anxiety

Recent literature has shown that application of virtual reality in cardiac invasive procedures can significantly reduce periprocedural anxiety (1,7,14–19,21). Table 2 summarises the different tools used to measure the anxiety levels and highlights the effectiveness of VR interventions based on different assessment tools. Micheluzzi V et al. on their first systematic review and meta-analysis of RCT on the use of VR for anxiety management during cardiac procedures determined that this technique lower periprocedural anxiety compared with standard care (SMD = - 0.51, 95% CI: -0.86 to -0.16 p=0.004) (1). Virtual reality has smoothed and diminished periprocedural anxiety during invasive coronary angiography, cardiac catheterization, catheter ablation of atrial fibrillation (FA), coronary computed tomography angiography (CCTA), transcatheter aortic valve replacement (TAVR), and transcatheter aortic valve implantation (TAVI) (8,9,11–

13,15,18,19,21). Visual analogue scale (VAS) and State-trait anxiety inventory (STAI) were the most commonly used scores to assess anxiety levels before and after the procedure (8,11–13,15,18,21). As a matter of fact, VR distraction has shown its effectiveness in reducing preprocedural anxiety and worries before numerous procedures compared with traditional oral and written information (14,16,21). Preprocedural education via VR HMD, englobing information about the setting, the equipments, the team, postprocedural complications and self-care, has increased patients' knowledge, self-efficacy and overall satisfaction and decreased their levels of anxiety (19). Older patients (≥ 65 years), women and patients with depression or anxiety disorders showed higher baseline anxiety. However, they reported higher satisfaction and felt less worried during the procedure than those who had received standard care (15,16,20). Additionally, VR is shown to be effective in reducing post-procedural potential stress (17).

Table 2. Anxiety Measurement Tools Used in VR Studies.

Study Reference	Anxiety Measurement Tool	Description of Tool	Pre-Procedure Anxiety Scores	Post-Procedure Anxiety Scores	Statistical Significance
Chang SL et al.2021 China	Anxiety levels out of 10	Anxiety, impatience, analgesia, and comfort assessed by blinded operators	7.4	5	NA
RB Bruno et al. 2020 Germany	Visual analogue scale (VAS)	Scale used to measure anxiety, anxiety-VAS cutoff value = 40	50	20	0.04
Morgan H et al.2021 UK	Mean anxiety score	The total score ranges from 0 to 63: 0-9, normal; 10-18, mild to moderate anxiety; 19-29, moderate to severe anxiety; 30-63, severe anxiety	VR group = 11.9 Control group = 13.1	VR group = 8.5 vs control group = 9.7	<0.05
Gölan BT et al. 2023 Turkey	Visual analogue scale (VAS)	Scale used to measure anxiety, anxiety-VAS cutoff value = 40	NA	VR group = 4.25 ± 1.80 Control group = 7.14 ± 0.91	<0.001
Lind et al. 2023 Germany	State Trait Anxiety Inventory (STAI-S)	Varies from 20 to 80 depending on the severity	NA	VR group = 31.5 ± 13.4 Control group = 38.5 ± 19.2	<0.05

Table 2 summarises the different tools used to measure the anxiety levels and highlights the effectiveness of VR interventions based on different assessment tools.

Patients' education and preparedness improvement

Virtual reality has made preprocedural education for patients easier and more efficient. Its utilization duration varies from 10 minutes to one day prior to the intervention (13). Patients were familiarized with the VR devices and taught about their manipulation (18). All the steps of the procedure were explained in the VR video before commencing including disinfection, draping, anaesthesia and incision (19). Any questions and doubts can be asked along any step of the process and they are being answered which is indirectly used to assess the knowledge (19). Therefore, results from RCT showed that VR significantly enhances patients' education and preparedness leading to improved procedural knowledge (16–19).

Impact of VR on patients' vital signs

With the use of Virtual reality before and during the procedure, there is a significant reduction in patients vital signs including, the heart rate, systolic and diastolic blood pressures as well as respiration rate (8,11,12,15). Additionally, VR increases significantly the oxygen saturation (11).

Pain management

A randomized controlled study conducted by Chang SL et al. in 2021 found that patients who had undergone catheter ablation for atrial fibrillation reported decreased pain compared to a paper-based education (19). Additionally, a systematic review and meta-analysis by Bashir Z et al. in 2024 confirmed that virtual reality (VR) significantly reduces pain during cardiac procedures such as angioplasty, CABG, and cardiac catheterization compared to standard care (7).

However, another systematic review and meta-analysis published in the same year by Micheluzzi V et al including RCT showed that VR does not significantly reduce pain in cardiac procedures (1).

Increased practitioners' knowledge

A prospective cross-sectional study by Chang SL et al. enrolled 52 participants (20 residents and 32 patients), 53% of whom had a history of depression or anxiety, showed an increase in the residents' knowledge, self-efficacy and satisfaction about the procedure before, after and at 2 weeks of receiving VR education training. The study reported also that the patients' knowledge, self-efficacy and satisfaction had increased after VR education from residents (20).

Limitations

A frequent limitation of many studies was the small sample size (15–19). In fact, findings of single-center trials with limited participants may not be generalizable to larger populations (15). Due to the nature of the intervention, it was not feasible to blind the patients, which could cause bias (1,19). Another limitation was the variability in results of different studies resulting from the use of different VR devices and software, duration of the intervention, dissimilarities between intervention and control groups as well as the variations in the timing of assessment of anxiety levels. The use of diverse questionnaires and anxiety scores constituted also a limitation when comparing results (1,7). Furthermore, the use of questionnaires and rating or scoring systems also makes the assessment of anxiety levels subjective (17–19,21). Some studies have a shorter duration of VR intervention, while others did not account for cybersickness as a side effect of VR use, which may have influenced the results (1,8,15,16). The COVID-19 pandemic also impacted some studies due to the premature ending of trials, cancellation of patient appointments, and postponement of cardiac procedures (17,18). Other limitations include not considering the effect of previous experiences with imaging methods like MRI or CT scan on STAI score and not standardizing confounding factors. All of which could have influenced the study results (15,22). Although VR has its benefits, it also imposes challenges, one of them being scalability, which can be solved by providing the right number of headsets or alternate access to users (14). Other challenges include the requirement of extra resources and time to prepare the VR equipment and solve problems during application (21).

Overall interpretation of the findings

Overall, the available evidence suggests that virtual reality is a promising adjunctive intervention for patients undergoing non-surgical cardiac procedures. Beyond its role as a distraction technique, VR appears to improve procedural understanding and patient preparedness, which may contribute to reducing anxiety and enhancing the overall patient experience. The literature also

indicates potential benefits on physiological parameters and post-procedural psychological outcomes. However, the current evidence remains limited by the heterogeneity of VR interventions, outcome measures, and study populations, as well as the relatively small sample sizes of most studies. Therefore, although the findings support the integration of VR into patient-centred cardiac care, larger, well-designed multicentre randomized controlled trials using standardized protocols are required before its routine implementation can be firmly recommended.

Recommendations

While virtual reality (VR) technology gained widespread acceptance in some countries, it remains underutilized in developing countries (14). In order to prevent patients from receiving inaccurate information from unreliable sources, developing VR content led by healthcare experts is recommended (1,17). Implementing cost-effective VR solutions, such as disposable cardboard viewers and smartphone-based experiences, has proved to be feasible and convenient (16,17). These methods reduced costs and enhanced accessibility, making immersive VR experiences more widely available (17). Utilizing virtual reality (VR) is recommended to ensure clear knowledge of procedures and medical interventions for patients (7). For instance, VR effectively illustrates atrial fibrillation (AF) during catheter ablation, aiding in pain and anxiety management (19). Additionally, using VR during transcatheter aortic valve implantation (TAVI) and multimedia education before coronary computed tomography angiography (CCTA) significantly reduces stress and anxiety, improves patient experience, enhances image quality, and lowers the risk of postoperative delirium (15,21). However, Bashir Z et al. concluded that VR for cardiac procedures should only be used with nature-based relaxing scenarios, have 30-minute sessions interspersed with 15-minute breaks, and begin with a 10-minute familiarization phase to assure safety and efficacy as represented in Figure 3 (7).

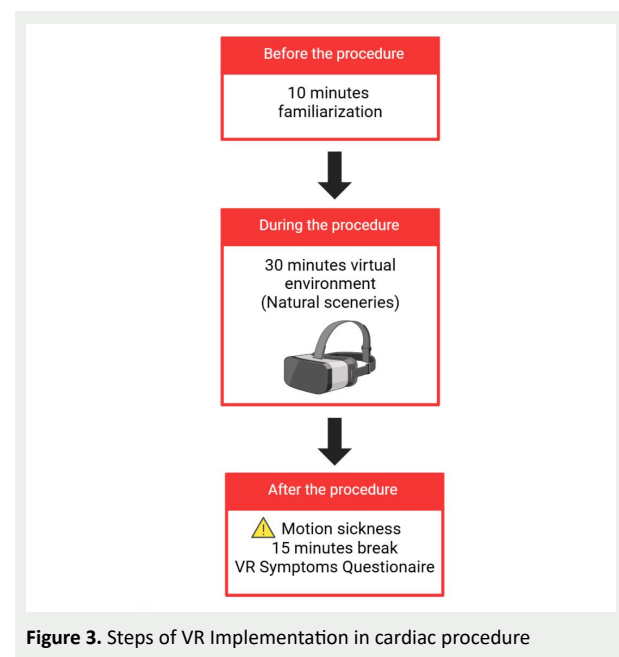


Figure 3. Steps of VR Implementation in cardiac procedure

Figure 3 represents the steps that should be followed by healthcare providers in the process of Virtual reality implementation as recommended by Bashir Z et al.

To optimize anxiety assessment, it is suggested to use validated tools specifically designed for accurate anxiety measurement (7). Integrating virtual reality (VR) with stress inoculation training (SIT) has successfully prevented stress-related reactions, including post-traumatic stress disorder (PTSD), and reduced the risk of adverse psychological outcomes (17). The State-Trait Anxiety Inventory (STAI) questionnaire's reliability and validity have been well-established through numerous studies, supporting its use in evaluating anxiety in healthcare interventions (17).

Virtual reality (VR) has proved to be a valuable tool in healthcare, not only for pain and anxiety management during invasive cardiac procedures, but also in various other utilizations such as VR exposure therapy, cardio-pulmonary rehabilitation, training, and education. Its effectiveness extended to decrease hospitalization length, stress levels, emotional tension, and depression, while also enhancing technical performance (7,14).

Areas of future research

Future studies should work on optimizing the length of the sessions, addressing adverse effects and developing VR content specifically for cardiac patients. Besides, using the Virtual Reality Symptom Questionnaire is crucial to keep an eye out for symptoms such as motion sickness regularly and look into ways to reduce cybersickness (7,14). Additionally, adopting software like extended reality systems (XRS) and the WebXR Device API can help with adaptability (14). Researchers should focus also on technical issues with equipment and patient's integration into clinical settings (10). Guaranteeing an appropriate supply of headsets and offering other access choices such as desktop and mobile devices is seemingly an important part to be worked on (15). Furthermore, researchers should also focus on increasing patient-staff communication and highlight patients' feedback in order to figure out if VR can be incorporated into daily clinical operations (10,15,19,20). Future studies should look into the effectiveness of VR in reducing patients' anxiety during other cardiac procedures and should account for patients' demographics, such as age and psychological well-being. It is also important to investigate its effects on patients' outcomes, satisfaction and cost-effectiveness (17). Furthermore, distributing preprocedural VR materials via cell phones like Google Cardboard constitute an affordable and accessible means for widespread application, which could be a potential field for future research (17). Further studies involving multiple centers should be conducted to explore VR's broader impact on patient outcomes across different medical settings and populations, highlighting its promises in improving psychological resilience and overall patient's experience during medical procedures as well as healthcare providers knowledge and effectiveness (17,22). Further multicentre randomized controlled trials involving larger and more diverse populations are needed

to confirm the effectiveness of VR across different cardiac procedures and to establish standardized protocols for its routine implementation in clinical practice.

CONCLUSION

Virtual reality is a promising technology in improving patients' psychological resilience and experience during medical procedures by significantly reducing periprocedural anxiety and improving patient education and preparedness. It may also contribute to better psychological outcomes; however, the evidence regarding pain reduction remains inconsistent. Potential adverse effects, including cybersickness, should also be considered when implementing VR in clinical practice. Further studies involving multiple centers should be conducted to explore VR's broader impact on patients' outcomes across different medical settings and populations and to establish standardized evidence-based recommendations for its routine use in cardiac care.

List of abbreviations:

ACS: Acute coronary syndrome; **AF:** Atrial Fibrillation; **BP:** Blood pressure; **CCTA:** Coronary computed tomography angiography; **DBP:** Diastolic blood pressure; **HMD:** Head-mounted display; **HR:** Heart rate; **ICD:** Implantable cardioverter defibrillator; **RCT:** Randomized clinical trial; **RR:** Respiratory rate; **SBP:** Systolic blood pressure; **STAI:** State- Trait Anxiety Inventory; **TAVI:** Transcatheter aortic valve implantation; **VAS:** Visual analogue scale; **VR:** Virtual reality

REFERENCES

1. Micheluzzi V, Burrai F, Casula M, Serra G, Shadi Al Omary, Pierluigi Merella, et al. Effectiveness of virtual reality on pain and anxiety in patients undergoing cardiac procedures: A systematic review and meta-analysis of randomized controlled trials. *Current Problems in Cardiology*. 2024 May 1;49 (5):102532–2.
2. Protogerou C, Fleeman N, Dwan K, Richardson M, Dundar Y, Hagger MS. Moderators of the effect of psychological interventions on depression and anxiety in cardiac surgery patients: A systematic review and meta-analysis. *Behaviour Research and Therapy*. 2015 Oct;73:151–64.
3. Celano CM, Daunis DJ, Lokko HN, Campbell KA, Huffman JC. Anxiety Disorders and Cardiovascular Disease. *Current Psychiatry Reports* [Internet]. 2016 Sep 26;18 (11). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5149447/>
4. Delewi R, Vlastra W, Rohling WJ, Wagenaar TC, Zwemstra M, Meesterma MG, et al. Anxiety levels of patients undergoing coronary procedures in the catheterization laboratory. *International Journal of Cardiology*. 2017 Feb;228:926–30.
5. Rousseaux F, Faymonville ME, Nyssen AS, Dardenne N, Ledoux D, Massion PB, et al. Can hypnosis and virtual reality reduce anxiety, pain and fatigue among patients who undergo cardiac surgery: a randomised controlled trial. *Trials*. 2020 Apr 15;21 (1).
6. Maples-Keller JL, Bunnell BE, Kim SJ, Rothbaum BO. The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. *Harvard Review of Psychiatry*. 2017;25 (3):103–13.
7. Bashir Z, Misquith C, Has P, Bukhari S. Effectiveness of virtual reality on anxiety and pain management in patients undergoing cardiac procedures: a protocol for systematic review and meta-analysis. *Open Heart* [Internet]. 2023 Jun 1;10 (1):e002305. Available from: <https://pubmed.ncbi.nlm.nih.gov/37399363/>
8. Keshvari M, Yeganeh MR, Paryad E, Roushan ZA, Pouralizadeh M. The effect of virtual reality distraction on reducing patients' anxiety

- before coronary angiography: a randomized clinical trial study. *The Egyptian Heart Journal*. 2021 Nov 4;73 (1).
9. Larsson CE, Verane Cabassut, Peretout P, Stéphanie Marliere, Vautrin E, Piliero N, et al. Assessment of the Objective Effect of Virtual Reality for Preoperative Anxiety in Interventional Cardiology. *The American Journal of Cardiology*. 2023 Aug 21;205:207–13.
 10. Helena E, Tjitske Diederike Groenvel, Garms L, Bonnes JL, Harry van Goor, Damman P. Virtual reality to reduce periprocedural anxiety during invasive coronary angiography: rationale and design of the VR InCard trial. *Open Heart*. 2024 Apr 1;11 (1):e002628–8.
 11. Gülcan Bahçecioğlu Turan, Fatma Gür, Zülfünaz Özer, Çağlar Tarkan. Effects of Virtual Reality on Pain, Anxiety, Patient Satisfaction in Coronary Angiography: A Randomized Trial. *Pain management nursing*. 2023 Dec 1;
 12. Esma Gökçe, Arslan S. Effects of virtual reality and acupressure interventions on pain, anxiety, vital signs and comfort in catheter extraction processes for patients undergoing coronary angiography: A randomized controlled trial. *International journal of nursing practice*. 2023 Jul 4;29 (6).
 13. Lind A, Majid Ahsan Esfahan, Matthias Totzeck, Fadi Al-Rashid, Haddad A, Dubler S, et al. Virtual reality-assisted distraction during transcatheter aortic valve implantation under local anaesthesia: A randomised study. *International Journal of Cardiology*. 2023 Sep 1;387:131130–0.
 14. Hamid Bouraghi, Mohammadpour A, Taleb Khodaveisi, Marjan Ghazisaeedi, Saeedi S, Sahar Familgarosian. Virtual Reality and Cardiac Diseases: A Systematic Review of Applications and Effects. *Journal of Healthcare Engineering [Internet]*. 2023 May 30 [cited 2023 Aug 21];2023:1–20. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10243949/>
 15. Paalimäki-Paakki K, Virtanen M, Henner A, Vähäniikkilä H, Nieminen MT, Schröderus-Salo T, et al. Effects of a 360° virtual counselling environment on patient anxiety and CCTA process time: A randomised controlled trial. *Radiography*. 2022 Oct;
 16. Hermans ANL, Betz K, Verhaert DVM, Dennis, Kristof J.H. Clerx, Debie L, et al. 360° Virtual reality to improve patient education and reduce anxiety towards atrial fibrillation ablation. *Europace*. 2023 Feb 4;25 (3):855–62.
 17. Aardoom JJ, Hilt AD, Woudenberg T, Chavannes NH, Atsma DE. A Preoperative Virtual Reality App for Patients Scheduled for Cardiac Catheterization: Pre–Post Questionnaire Study Examining Feasibility, Usability, and Acceptability. *JMIR Cardio*. 2022 Feb 22;6 (1):e29473.
 18. Morgan H, Nana M, Phillips D, Gallagher S. The Effect of a Virtual Reality Immersive Experience Upon Anxiety Levels, Procedural Understanding, and Satisfaction in Patients Undergoing Cardiac Catheterization: The VIRTUAL CATH Trial. *The Journal of Invasive Cardiology [Internet]*. 2021 Sep 1;33 (9):E681–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/34398809/>
 19. Chang SL, Kuo MJ, Lin YJ, Chen SA, Yang YY, Cheng HM, et al. Virtual reality informative aids increase residents' atrial fibrillation ablation procedures-related knowledge and patients' satisfaction. *Journal of the Chinese Medical Association*. 2020 Dec 31;84 (1):25–32.
 20. Chang SL, Kuo MJ, Lin YJ, Chen SA, Yang YY, Cheng HM, et al. Virtual reality informative aids increase residents' atrial fibrillation ablation procedures-related knowledge and patients' satisfaction. *Journal of the Chinese Medical Association*. 2020 Dec 31;84 (1):25–32.
 21. Bruno RR, Lin Y, Wolff G, Polzin A, Veulemans V, Klein K, et al. Virtual reality-assisted conscious sedation during transcatheter aortic valve implantation: a randomised pilot study. *EuroIntervention: Journal of EuroPCR in Collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology [Internet]*. 2020 Dec 18;16 (12):e1014–20. Available from: <https://pubmed.ncbi.nlm.nih.gov/32597390/>
 22. Zablah JE, Rodríguez SA, Leahy R, Morgan GJ. Implementation of virtual reality for patient distraction during diagnostic cardiac catheterisation. *Cardiology in the Young*. 2021 Jul 26;1–5.