Transforming Early Phase I Post-CABG Rehabilitation: Evidence, Technology Integration, and Future Directions

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ABSTRACT

Coronary artery bypass grafting (CABG), while life-saving, initiates significant postoperative deconditioning. Historically, cardiac rehabilitation (CR) has focused on later phases, neglecting the critical early postoperative period. This review evaluates the safety, efficacy, and future direction of early Phase I CR, initiated within 72 hours post-CABG.

Drawing from randomized controlled trials, meta-analyses, and nationwide cohort studies, this review synthesizes evidence supporting early rehabilitation's clinical benefits. Functional outcomes (e.g., Barthel Index, 6-minute walk distance) and health system efficiencies (e.g., reduced ICU stay, cost savings) are analyzed alongside technology-enhanced strategies such as augmented reality (AR), virtual reality (VR), and digital twin modeling.

Early Phase I CR demonstrates improved functional recovery (+54 m in 6MWD), reduced hospital/ICU stays, and no increase in adverse events. Technological adjuncts improve patient engagement, safety monitoring, and adherence. Economic analyses report substantial cost-effectiveness, with ICERs ranging from $2,000 to $28,000 per life-year gained. Limitations include variability in protocols, resource disparities, and lack of long-term survival data.

Early Phase I CR post-CABG is clinically safe, functionally effective, and economically advantageous. Integration of AR/VR and digital tools promises further personalization and scalability. Future research should focus on long-term outcomes, protocol standardization, and equitable implementation across diverse populations.

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Introduction

CABG, or coronary artery bypass grafting, is an essential surgical treatment for those dealing with significant, multivessel coronary artery problems. Although this surgical procedure effectively reinstates myocardial perfusion and mitigates anginal manifestations, it concurrently elicits considerable physiological strain. Such stress frequently culminates in muscular deconditioning, compromised pulmonary function, an increased likelihood of postoperative pneumonia, thrombotic complications, and weakness acquired in the intensive care unit, all of which have the potential to prolong recovery and undermine clinical outcomes [1]. Traditional cardiac rehabilitation (phases II–III) generally commences several weeks subsequent to surgical intervention, with an emphasis on the enhancement of exercise capacity, management of risk factors, and improvements in quality of life. Nevertheless, this deferred initiation neglects a critical early phase during which functional deterioration commences and complications may potentially emerge. An increasingly compelling body of evidence now substantiates the implementation of early Phase I rehabilitation, which is initiated within a timeframe of 72 hours to 7 days following coronary artery bypass grafting (CABG): Randomized controlled trial (Han et al., n = 150) indicated that patients allocated to early rehabilitation within intensive care unit (ICU) and/or ward environments exhibited significantly elevated scores on the Barthel Index at the point of discharge (86–89 vs. 75), along with reduced durations of ICU and overall hospital admissions—without a concomitant increase in pulmonary or cardiac complications [2]. Meta-analysis of randomized controlled trials (n = 391) synthesized data from six distinct studies, revealing a clinically significant enhancement of +54 m in the 6-minute walk distance at discharge subsequent to the implementation of early mobilization strategies [3]. Real-world, nationwide cohort (Ohbe et al., n = 30,568) Patients who initiated rehabilitation within a 3-day period following CABG exhibited a +3.2 point enhancement in the Barthel Index upon discharge, in conjunction with a reduction in in-hospital mortality rates, diminished ICU/hospital length of stay, and lowered overall costs [4]. These results suggest that Phase I rehabilitation subsequent to CABG is not only safe and feasible but also efficacious in fostering early functional recovery, minimizing hospital durations, and curtailing expenses. Nevertheless, several pivotal inquiries persist: Optimal initiation timing: The earliest safe interval

(within 24 hours) as opposed to the traditionally acknowledged 72-hour threshold necessitates elucidation. Program composition: The specific contributions of respiratory exercises, psychological support, physiotherapeutic interventions, and digital enhancements necessitate further elaboration. Long-term outcomes: The empirical evidence correlating early rehabilitation with diminished readmission rates, enhanced long-term survival, and prolonged functional improvements post-discharge is currently insufficient. This review conducts a systematic assessment of the prevailing literature regarding early Phase I rehabilitation post-CABG—emphasizing the aspects of timing, protocol design, efficacy, safety, economic ramifications, and the potential for enduring recovery—intending to bolster evidence-based clinical practice.

Definitions and Terminology

2.1 Phases of Cardiac Rehabilitation

Cardiac rehabilitation is typically organized into three distinct phases, with the possibility of an additional fourth phase in certain models [1]: Phase I (Inpatient/Early) – Initiates within the hospital setting shortly following a cardiac event or surgical intervention (e.g., CABG), generally lasting from 2 to 7 days. Essential elements encompass early mobility, educational initiatives, and discharge planning [1,2,4]. Phase II (Subacute Outpatient) – Takes place post-discharge for a duration of 3 to 12 weeks, emphasizing supervised physical exercise, management of risk factors, and education related to lifestyle modifications [2,8]. Phase III (Maintenance) – Advocates for the promotion of long-term independent exercise routines and the continuation of lifestyle changes [2,6,8,14]. Phase IV (Extended/Telerehabilitation) – Functions as a means of ongoing maintenance facilitated through home-based, community-oriented, or remote platforms [6,12].

2.2 Defining "Early Rehabilitation" (Phase I)

Phase I rehabilitation pertains to inpatient interventions that are commenced within the initial 72 hours to one week following coronary artery bypass grafting (CABG): This phase encompasses a preliminary assessment, gentle mobilization at the bedside, and respiratory exercises including deep breathing techniques and the use of incentive spirometry. The primary focus is on education—imparting knowledge to patients regarding self-monitoring, wound management, and the safe advancement toward ambulation. This phase underscores the importance of multidisciplinary oversight, involving cardiologists, physiotherapists, and nursing professionals, to guarantee a secure progression during recovery [2,4,6].

2.3 ERAS / "Fast-Track" in Cardiac Surgery

The Enhanced Recovery After Surgery (ERAS) protocol constitutes a comprehensive multidisciplinary care framework that is systematically implemented throughout the preoperative, intraoperative, and postoperative phases [3,5,7]: Preoperative: optimization of risk factors and thorough patient preparation. Intraoperative: utilization of minimally invasive surgical techniques and goal-directed anesthesia management. Postoperative: facilitation of early extubation, effective analgesia, and mobilization commencing as early as hours following the surgical procedure. In the domain of cardiac operations, the ERAS protocol has revealed a substantial reduction in ICU and hospital stay durations, lessens complications (like atrial fibrillation), and curtails overall healthcare costs [3,5,7,13].

2.4 Criteria for Initiating Phase I

The criteria for safe inclusion in early rehabilitation typically encompass the following: Timing: within a 72-hour timeframe post-operatively (occasionally extending to day 7). Hemodynamic stability: maintenance of stable vital signs, appropriately managed pain, and absence of active hemorrhage. Respiratory readiness: either complete removal from ventilatory support or with minimal reliance on such support. Multidisciplinary oversight: engagement of a physiotherapist, cardiologist, and nursing personnel [1,2,5,8].

2.5 Distinction Between Phases I and II

Phase I transpires within the confines of the hospital environment and accentuates the fundamental recovery and readiness for discharge. Phase II is conducted in outpatient facilities, providing organized aerobic and resistance training under meticulous supervision [2,8,14].

Efficacy and Safety of Early (Phase I) Rehabilitation

Early rehabilitation—typically initiated within the first 1–3 days post-CABG—has shown compelling evidence of functional benefit and clinical safety when applied in a structured, monitored framework.

3.1 Functional Outcomes

A Randomized Controlled Trial led by Han and associates (n = 150) illustrated that rehabilitation groups, whether in the Intensive Care Unit (ICU) or standard wards, achieved notable advancements in Barthel Index scores at the discharge stage (86–89) when compared to typical care protocols (75), without resulting in heightened pulmonary complications or atrial fibrillation events. Furthermore, both early intervention groups were found to have reduced durations of stay in the ICU and overall hospital settings [2,4].

Meta-analysis of RCTs (n = 391) Analysis of six trials revealed that early mobilization during postoperative days 1–2 resulted in a clinically significant increase in 6-minute walk distance by +54 m at discharge (95% CI 31–77 m), exceeding the recognized minimal important difference [3,6].

Meta-analysis of randomized controlled trials (n = 391) The examination of six independent trials indicated that early mobilization on postoperative days 1 to 2 led to a statistically significant enhancement in the 6-minute walk distance, demonstrating an increase of +54 m at the time of discharge (95% confidence interval 31–77 m), surpassing the established minimal important difference [3,6].

3.2 Safety Profile

No randomized controlled trial (RCT) has documented a rise in postoperative pulmonary complications, atrial fibrillation, or wound-related morbidity associated with early rehabilitation interventions [2,3]. Minor variations in heart rate and lactate concentrations were observed during the initial mobilization phase; however, these variations subsided without detrimental consequences under appropriate surveillance [3,8].

3.3 System Efficiency and Patient-Centered Benefits

The commencement of early mobilization has shown a correlation with shorter intensive care unit (ICU) and overall hospital stays, yielding an average decline of 0.5 to 2 days in the ICU along with several additional days in total. The amalgamation of reduced lengths of stay with enhanced program efficiency has yielded substantial financial savings—frequently exceeding 20 to 50 percent for each episode of care [1,5,9].

3.4 Ongoing Limitations

Protocol inconsistency: Discrepancies in the timing, frequency, and specific interventions are evident across various studies [3,6]. Resource requirements: The implementation of early rehabilitation necessitates training, adequate staffing, and effective coordination, which may not be achievable in all clinical settings [3,8]. Long-term outcomes: The majority of the existing evidence pertains to in-hospital effects. There is a paucity of prospective data that correlates Phase I rehabilitation with long-term survival, readmission rates, and overall quality of life [6,9].

Safety and Risks of Early (Phase I) Rehabilitation

Extensive evidence derived from randomized controlled trials, systematic reviews, and quality enhancement programs indicates that Phase I rehabilitation following coronary artery bypass grafting (CABG) is deemed safe when administered within a meticulously organized and closely supervised setting.

4.1 Serious Adverse Events: Rare or Absent

In investigations pertaining to early mobilization, significant complications—such as substantial hemodynamic instability, myocardial ischemia, or wound dehiscence—were infrequently observed, contingent upon adherence to established safety protocols and pre-mobilization evaluations [1]. In the seminal randomized controlled trial conducted by Han et al., the implementation of early rehabilitation during intensive care unit and ward recovery phases did not lead to an escalation in pulmonary complications or atrial fibrillation when juxtaposed with standard care protocols [2]. No adverse events were documented across the randomized controlled trials encompassed within a meta-analysis of six studies (total n = 391), thereby substantiating the perspective that early rehabilitation is clinically safe [3,4].

4.2 Transient Physiological Responses – Manageable

Transitory elevations in heart rate, blood pressure, and lactate levels are commonly noted during the initial phases of mobilization; however, these responses are typically self-resolving and can be effectively managed under appropriate clinical oversight [4,5]. Furthermore, these physiological alterations did not correlate with any prolonged complications or necessitate rehospitalization [3].

4.3 Arrhythmia Risk Must Be Considered

Atrial fibrillation influences a substantial proportion, specifically 15–40%, of patients undergoing coronary artery bypass grafting (CABG), thereby presenting a theoretical apprehension regarding the initiation of early exercise interventions [6]. Nonetheless, investigations that have documented the outcomes of early mobilization—when combined with conventional arrhythmia management—revealed no statistically significant escalation in the incidence of arrhythmias [2].

4.4 Contraindications and Safety Checkpoints

Early rehabilitation should be postponed or modified in the context of: hemodynamic instability, characterized by uncontrolled hypertension, hypotension, or significant tachyarrhythmias, whether tachycardic or bradycardic. The presence of active hemorrhage or increased output from chest tubes is also a critical factor. Respiratory compromise, as evidenced by the necessity for ongoing mechanical ventilation or dependence on supplemental oxygen, must be taken into account. Furthermore, conditions such as severe pain, uncontrolled infections, or altered cognitive status preclude individuals from participating in early mobilization until their stability is reestablished [1,3].

4.5 System-Level Safety Support

Multidisciplinary supervision—comprising a cardiologist, a physiotherapist, and nursing personnel—is imperative for the safety of early rehabilitation, facilitating the prompt identification of adverse indicators. The implementation of standardized mobility protocols, vital sign benchmarks, and exercise progression criteria significantly augments patient safety across various clinical environments [1,2].

Progressive Physical Activity

Initial mobilization (bed exercises → sitting → standing → walking): This process commences in the Intensive Care Unit (ICU) and advances daily to enhance muscular strength and mitigate the effects of deconditioning [2]. Aerobic training: Low-intensity endeavors such as ambulation beside the bed or utilization of a stationary bicycle are initiated 24–48 hours post-surgery, adhering to the FITT principles (frequency, intensity, time, type)—typically involving moderate levels of exertion (Borg 11–13) [6,14]. Resistance training: The introduction of light resistance, employing bands or utilizing body weight, is implemented as tolerated and serves to augment functional capacity even during the period of hospitalization [5,8,10].

5.2 Respiratory Physiotherapy

Breathing exercises and incentive spirometry: The implementation of deep breathing techniques, the utilization of incentive spirometry, alongside effective coughing maneuvers serves to mitigate the risk of pulmonary complications, maintain lung volumes, and optimize oxygenation [0,2,7]. Chest physiotherapy: The integration of postural drainage, the active cycle of breathing techniques (ACBT), in conjunction with percussion, plays a critical role in the clearance of secretions and the attenuation of atelectasis risk [2,22].

5.3 Education and Psychosocial Support

Patient instruction: The implementation of secure transfer methodologies, the practice of energy conservation, the vigilant observation of symptoms (including heart rate, physical exertion, and oxygen desaturation), as well as the management of wound care [2,5,12]. Psychosocial engagement: The mitigation of anxiety and stress through interventions such as counseling, mindfulness practices, or adaptive coping strategies is essential for enhancing adherence and promoting overall recovery outcomes [17,21].

5.4 Multidisciplinary Care and Monitoring

Coordinated supervision: A collaborative team comprising physiotherapists, nurses, and cardiologists guarantees patient safety, modulates exercise intensity, and monitors critical physiological thresholds [3]. Physiological surveillance: Ongoing evaluation of heart rate, blood pressure, oxygen saturation, and subjective exertion levels informs therapeutic advancement and mitigates the risk of complications [12,22].

5.5 Innovative Adjuncts

Inspiratory muscle training: Focused enhancement of respiratory musculature augments pulmonary function and facilitates early extubation [5]. Technology-enhanced tools: Digital rehabilitation platforms, wearable biometric sensors, and immersive virtual reality environments may improve adherence and promote sustained home-based interventions [2,20].

Medical, Social, and Economic Impact of Early Phase I Rehabilitation

The application of well-structured early rehabilitation protocols (commenced within 72 hours post-CABG) confers considerable advantages in terms of clinical outcomes, healthcare resource utilization, and socio-economic aspects. A study in Saudi Arabia involving a randomized controlled trial showcased that patient participation in early mobilization notably lessened their ICU duration from 5.0 days to 2.14 days and their hospital stay from 8.73 days to 6.56 days, achieving a significant 53% reduction in ICU costs (about US $17,538) alongside a 46% decrease in total hospital expenses (approximately US $16,512) [1,2]. Additional quality improvement initiatives: The adoption of mobilization protocols throughout the ICU and general wards resulted in a 20% decrease in ICU durations, a 40% decrease in ward durations, and annual hospital cost savings amounting to $1.5 million [4].

6.2 Cost-Effectiveness

The ICER values for exercise-focused cardiac rehabilitation lie between $2,000 and $28,000 for every life-year gained, thereby indicating a meaningful level of cost-effectiveness [5,13]. Furthermore, an additional review identified the cost per Quality-Adjusted Life Year (QALY) to fall between $700 and $16,000, a figure that remains well within the established thresholds for acceptability [5,15].

6.3 Long-Term Outcomes and System Efficiencies

Research on telerehabilitation indicates that prompt and sustained involvement is correlated with diminished rates of rehospitalization and advantageous economic outcomes over time [23]. Home-based cardiac rehabilitation demonstrates comparable cost-effectiveness to center-based programs, while additionally offering enhanced convenience [11,20].

6.4 Social and Patient-Centered Benefits

Expedited discharge facilitates an earlier return to the home environment for patients, thereby alleviating psychosocial stressors and diminishing the burden placed upon caregivers. The mitigation of out-of-pocket expenses—a critical factor influencing adherence—occurs when early rehabilitation strategies effectively curtail hospital-related costs [11,20].

6.5 Implementation and Equity Challenges

Resource requirements: The successful implementation of early rehabilitation necessitates the presence of committed physiotherapy personnel, adequate training, effective coordination within intensive care units, and

appropriate physical space—resources that are not uniformly accessible across all healthcare settings [4]. Access disparities: Populations residing in rural or underserved areas may encounter significant barriers to obtaining early rehabilitation services in the absence of telehealth innovations or supportive policy measures [20,23]. Health system alignment: Traditional fee-for-service reimbursement models may not provide sufficient incentives for protocols aimed at minimizing length of hospital stay; alternatively, value-based care frameworks are more conducive to the advancement of early Phase I rehabilitation programs [4,11].

Barriers and Limitations to Implementing Early (Phase I) Rehabilitation

Notwithstanding the robust evidence endorsing early-phase rehabilitation subsequent to Coronary Artery Bypass Grafting (CABG), the practical execution of such initiatives encounters a myriad of challenges at the levels of patients, institutions, and healthcare systems. It is imperative to identify these impediments in order to formulate sustainable, equitable, and efficacious rehabilitation programs.

7.1 Patient-Level Barriers

Low motivation and psychological determinants: The apprehension of potential complications, heightened anxiety levels, and diminished self-efficacy markedly hinder participation, even within inpatient Phase I environments [1,16]. Comorbidities and demographic factors: Advanced chronological age, the presence of multiple chronic health conditions, lower educational attainment, and linguistic obstacles have consistently been associated with a decreased engagement in rehabilitation programs [5-11,18,29-30]. Insufficient awareness and financial constraints: A considerable number of patients lack comprehension regarding the advantages of early rehabilitative interventions, while expenses incurred out-of-pocket or difficulties related to transportation further obstruct adherence to such programs [5,10].

7.2 Institutional Level Barriers

Staffing and resource constraints: The restricted availability of qualified physiotherapists, challenges in interdisciplinary coordination, and inadequate equipment in intensive care unit or ward environments impede the effective implementation of the program [1,17-20,23-28]. Referral & integration issues: In spite of established guidelines, early rehabilitation referrals are not consistently prioritized by surgical teams, leading to delays or the loss of potential opportunities [12,7].

7.3 System-Level and Policy Barriers

Health system fragmentation: In numerous geographical locales, the provision of cardiac rehabilitation is characterized by a deficiency of cohesive pathways, electronic referral mechanisms, or telehealth facilitation, particularly within rural and economically disadvantaged populations [20,16]. Reimbursement and incentive misalignment: Systems predicated on fee-for-service models may fail to provide adequate incentives for early rehabilitation interventions, particularly in contexts where abbreviated hospital admissions diminish the revenue accrued per clinical case [1,5].

7.4 Research and Evidence Limitations

Protocol heterogeneity: The existing body of literature exhibits considerable variability in terms of timing, frequency of sessions, intensity, and various components, thereby complicating the endeavor to generalize conclusions [1,3]. Adherence and dropout issues: Non-adherence within clinical trials introduces potential biases and diminishes the quantifiable effect sizes [3,16]. Deficient long-range data: Although there has been ample documentation of short-term outcomes, there remains a conspicuous scarcity of investigations into the effects of Phase I rehabilitation on long-term survival, readmission frequencies, or the quality of life overall [3,16,6].

Future Directions and Emerging Trends in Early (Phase I) Rehabilitation

Groundbreaking innovations encompassing augmented reality (AR), virtual reality (VR), and digital twin modeling are enhancing the realm of early cardiac rehabilitation. Prospective initiatives are anticipated to improve customization, patient involvement, and clinical outcomes through the incorporation of sophisticated digital instruments and the optimization of ERAS-based protocols.

8.1 Augmented and Virtual Reality

A current randomized clinical investigation executed in Iran (n = 60) incorporated augmented reality (AR) throughout Phase I rehabilitation for patients who are undergoing coronary artery bypass grafting (CABG) in the intensive care unit (ICU). The cohort utilizing AR demonstrated a statistically significant enhancement in self-efficacy regarding the management of cardiovascular exercises when compared to the standard educational controls at the time of discharge ($p < 0.001$) [1,2,3]. Comprehensive evaluations of AR/VR applications within the domain of cardiac rehabilitation indicate that these technological interventions possess the potential to mitigate procedural anxiety, enhance patient engagement, and facilitate cognitive recovery following surgical interventions [5,7,21-24,30-33].

8.2 Digital Twin Technology

Advancements in the realm of cardiovascular digital twin modeling—characterized by the iterative updating of patient-specific three-dimensional cardiac representations through advanced imaging techniques and data integration—present a remarkable opportunity to customize rehabilitation protocols in real time and to anticipate individual responses to varying levels of exercise intensity and timing [44,46]. Comprehensive systematic reviews underscore the noteworthy innovations in personalized cardiac care arising from the integration of AI-enhanced digital twins with augmented and virtual reality technologies [6].

8.3 Tele-Rehab and Home-Based Continuation

Hybrid telehealth initiatives have exhibited both feasibility and effectiveness for individuals with cardiovascular disease; a specific 12-week program resulted in a +40 m enhancement in the 6-minute walk distance without any reported adverse events [17-22]. These platforms effectively mitigate the discontinuity between inpatient Phase I rehabilitation and outpatient continuity, thereby providing seamless rehabilitation experiences.

8.4 ERAS Integration

The implementation of Enhanced Recovery After Surgery (ERAS) protocols in the domain of cardiac surgery now integrates early mobilization, nutritional support, and pain management strategies. Recent scholarly evaluations highlight that the application of augmented reality and virtual reality (AR/VR) in ERAS frameworks is linked with superior clinical results, such as diminished ICU stay durations and a decline in pulmonary complications [25-30,41-46]. Emerging scholarly investigations elucidate significant deficiencies in early Phase I cardiac rehabilitation—especially concerning the effectiveness of augmented reality/virtual reality (AR/VR), digital twins, the integration of Enhanced Recovery After Surgery (ERAS) protocols, and long-term outcomes—indicating an imperative requirement for multicenter randomized controlled trials (RCTs) that associate these technologies with functional recovery, pilot studies that evaluate simulation-guided mobilization, comparative ERAS-plus-digital trials, and extended follow-up assessments surpassing 12 months. Subsequent proposed investigations ought to encompass RCTs contrasting AR/VR-augmented rehabilitation with conventional care, pilot studies utilizing digital-twin–guided mobilization, and telerehabilitation continuity trials that evaluate readmissions and functional outcomes.

Conclusion and Future Outlook

The rollout of rehabilitation during the initial Phase I interval, especially within a 72-hour timeframe subsequent to Coronary Artery Bypass Grafting (CABG), has indicated noteworthy short-term advantages, comprising improved functional recovery, better safety, diminished healthcare resource allocation, and increased cost-efficiency. However, the transition of these transient benefits into sustained long-term outcomes necessitates ongoing innovation and rigorous research.

9.1 Synthesis of Current Findings

The initial phase of rehabilitation following coronary artery bypass grafting (CABG) has been demonstrated to enhance functional autonomy and exercise capability at the time of discharge, concurrently preserving a robust safety profile, diminishing intensive care unit and hospital durations, and mitigating associated costs; furthermore, it reveals an augmented level of patient involvement through augmented reality/virtual reality (AR/VR), individualized planning utilizing digital twins, and prolonged cardiopulmonary advantages derived from hybrid tele-rehabilitation models [31–37].

9.2 Long-Term Impact & Research Needs

Rehabilitation Phase I post Coronary Artery Bypass Grafting (CABG) indicates specific benefits during hospital care; however, a gap remains in current empirical findings that prove it positively influences long-term survival rates, Major Adverse Cardiovascular and Cerebrovascular Events (MACCE), or prolonged functional capacity. Moreover, there are notable deficiencies in the integration of protocols into Phases II–III and telerehabilitation, as well as in the inclusion of older adults, female participants, and individuals with significant comorbidities, alongside the absence of formalized dose-response guidelines. Consequently, there is an urgent imperative for research aimed at evaluating these outcomes, optimizing engagement across diverse subgroups, and establishing standardized measures for intensity and progression [24,37,38,40].

9.3 Strategic Recommendations & Future Research

Clinical methodologies for Phase I rehabilitation subsequent to coronary artery bypass grafting (CABG) should encompass standardized protocols for early initiation, augmented by augmented reality (AR)/virtual reality (VR) and digital technological tools, facilitate seamless transitions from inpatient to outpatient and telerehabilitation through automated referral processes, and be subjected to thorough randomized controlled trials (RCTs) that assess variables such as timing, the integration of technology, and individualization—preferably with a follow-up duration of at least one year and a heterogeneous representation of patient demographics.

9.4 Final Perspective

The rehabilitation process during Phase I transcends the mere immediate postoperative intervention—it constitutes the fundamental basis for a comprehensive continuum of cardiac recovery. Through the integration of digital innovations, the enhancement of patient-centered pathways, and the meticulous evaluation of long-term outcomes, early rehabilitation possesses the potential to evolve into a transformative and individualized standard of care. This cohesive, evidence-informed model not only aspires to optimize patient recovery but also aims to redefine the concept of value within the realm of cardiac surgical care.

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