3. Phase I—Early Mobilization

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3.1. Idea of Early Mobilization

Bed rest and immobility have been the recommended standard of care following acute cardiac events for many decades [1]. The implementation of early mobilization was gradual, from chair therapy in the 1940s, to several minutes of walks after four weeks of rest in the 1950s and mobilizing patients after 12 days of rest in the 1960s [2]. A study conducted by Saltin in 1968 revealed the problem of the vicious cycle of prolonged hospital bed rest [3]. Prolonged hospital bed rest contributes to decreased cardiac output; secondary complications such as deep venous thrombosis, pneumonia, pressure sores, a rapid loss of skeletal muscle mass, reduced strength, and a decline in aerobic capacity [4,5]. Early mobilization means the initiation of mobilization activities as soon as clinical stability is achieved, typically with 1–2 days of admission, and has significant effects on the length of hospital stay and the readmission rate [6,7].

Goals of early mobilization include [8,9]:

- Limiting physical inactivity and preventing bed rest complications.
- Maintaining physical activity at the required level.
- Preparing patients for performing activities of daily living.
- Reducing disease-related stress and anxiety.
- Preparing patients for a return to work.

3.2. Early Mobilization after Myocardial Infarction

Cardiac rehabilitation should start immediately after clinical stabilization, usually at a coronary care unit, after 12–48 h [8]. The progression of the mobilization depends on the clinical course and the potential complications. All patients with myocardial infarction should be monitored for at least 24 h after an acute event and longer in cases wherein there is a high risk of arrhythmia, hemodynamic instability, severe impairment of left ventricular systolic function, unsuccessful reperfusion, or multivessel coronary disease [10].

The patient is considered appropriate for daily ambulation and mobilization if [11]:

- There has been no recurrent chest pain during the previous 8 h;
- Neither troponin nor CK-MB levels are rising;

- No new, significant abnormal rhythm or ECG ischemic changes have occurred during the previous 8 h period.

Absolute contraindications for mobilization are:

- Decompensated heart failure;
- Systolic blood pressure > 200 mmHg and diastolic > 100 mmHg;
- Complete atrioventricular block without a pacemaker;
- Endocarditis and pericarditis;
- Thrombophlebitis.

Mobilization should be stopped in the case of:

- Angina;
- Dyspnea;
- Heart rate increase > 20/min;
- Heart rate drop > 10/min;
- Complex, exercise-induced arrhythmia;
- Decrease in systolic blood pressure > 10–15 mmHg;
- Increase in systolic blood pressure of >40 mmHg and/or diastolic blood pressure of >20 mmHg compared with resting values.

Exercises are recommended to be performed twice a day, optimally on every day of the week. Blood pressure and heart rate should be checked before, during, and after exercises [10]. The key elements of the early mobilization period remain supervision during training, the regular evaluation of training response and progress, the management of clinical symptoms of hypotension, the assessment of fluid status, heart rate control, and pharmacological treatment modification. The importance of early mobilization following myocardial infarction has been well established, and a growing body of evidence suggests the improvement of the inflammatory response and impact on the ventricular remodeling process [12,13]. However, some discrepancy between the recommendations and clinical practice exists with regard to bed rest time following myocardial infarction. According to the study conducted by Cortez, mobilization in the coronary care unit takes place late, nearly 50 h after the onset of myocardial infarct, and patients spend up to 70% of their time on bed rest [14,15].

The authors of this book want to present an adapted model of early mobilization utilized widely in Poland described in Tables 16–18 (A1, A2, and B pathways):

Table 16. Suggested first stage of early mobilization after myocardial infarction.

Mobilization duration	A1: days 0–1; A2: days 0–2; B: days 0–3
Exercise duration	5–10 min, twice a day
Position of exercises	Supine position, semi-sitting, sitting
Type of exercises	Respiratory exercises Isometric exercises of small muscle groups Dynamic exercises, initially of small muscle groups, then major muscle groups Relaxation exercises
Activities	Semi-sitting position in bed Sitting in an armchair Turning to the side in bed Personal care in bed

Source: Table by authors.

Table 17. Suggested second stage of early mobilization after myocardial infarction.

Mobilization duration	A1: day 2; A2: days 2–3; B: days 4–8
Exercise duration	10–15 min twice a day
Position of exercises	Sitting
Type of exercises	As in stage 1, with an intensity increase—i.e., increased number of repetitions, or at increased pace, or the number of sets Dynamic exercises of extremities Coordination exercises Short walks
Activities	Active sitting in an armchair Eating in a sitting position in bed Transport to toilet in a wheelchair Standing up and taking a short walk around the room

Source: Table by authors.

Table 18. Suggested third stage of early mobilization after myocardial infarction.

Mobilization duration	A1: days 3–5; A2: days 4–8; B: from day 8
Exercise duration	20 min twice a day
Position of exercises	Sitting, standing, walking
Type of exercises	As in stage II with gradual intensity increase Gradual increase in walking distance up to 300 m Climbing upstairs
Activities	Complete mobilization

Source: Table by authors.

A model

The A1 model applies to the following groups of patients:

- Those with unstable angina;
- Those with uncomplicated myocardial infarction (NSTEMI, STEMI without significant impairment of the left ventricular systolic function).

The A2 model is dedicated to patients:

- With a myocardial infarction and significantly impaired left ventricular systolic function;
- Who have undergone uncomplicated cardiac surgery.

The B model applies to:

- Patients with a complicated myocardial infarction;
- Patients after cardiac surgery with a complicated early postoperative course;
- Patients who have undergone transcatheter aortic valve implantation;
- Patients who have undergone the implantation of a ventricular assistance device;
- Patients who have undergone orthotopic heart transplantation;
- Patients with heart failure.

In all presented models, mobilization comprises three stages (Tables 16–18).

3.3. Early Mobilization after Cardiac Surgery

3.3.1. Prehabilitation

The detrimental effects of prolonged bed rest in an intensive care unit have been extensively investigated. Prolonged immobilization contributes to decreased cardiac output; the development of complications such as deep venous thrombosis, pneumonia, pressure sores, and muscle atrophy; and a decline in aerobic capacity, which occurs as early as within the first few postoperative days [16]. Muscle weakness has been observed in nearly 50% of intensive care patients and is strongly associated with increased short- and long-term morbidity, the deterioration of physical capacity, and an increase in mortality [17,18]. Furthermore, patients undergoing cardiac surgery are at a risk of postoperative pulmonary complications leading to increased postoperative morbidity and mortality. These include cardiogenic pulmonary edema, acute respiratory distress syndrome, pneumothorax, pleural effusion, atelectasis, pneumonia, prolonged mechanical ventilation, and phrenic nerve injury [19]. Contributing factors include age over 70 years, diabetes mellitus, body mass index > 28, and preoperative arrhythmias [20]. Thus, preoperative assessment should entail the testing of functional capacity and frailty for an appropriate postoperative risk estimation. The inability to climb two flights

of stairs or the presence of frailty is associated with a high risk of postoperative cardiac events [21,22]. Cardiac prehabilitation implements specific interventions before cardiac surgery to facilitate better postoperative outcomes [23].

Detailed goals of prehabilitation include:

- Reduction in the risk of thrombo-embolic events;
- Reduction in the risk of respiratory complications;
- Maintaining the function of the peripheral muscles;
- Minimizing postoperative stress.

Prehabilitation comprises:

- Education about the procedure and postoperative course, including potential complications;
- Inspiratory muscle training;
- Coughing exercises;
- Appropriate methods of changing position in bed;
- Low-intensity exercises, adapted individually to a patient's clinical status;
- Psychotherapeutic support.

Respiratory physiotherapy is of paramount importance and includes such practices as secretion aspiration, oxygen therapy, change in body positions, postural drainage, deep breathing/coughing exercises, inspiratory muscle training, and the use of incentive spirometers [24–26].

3.3.2. Early Mobilization

Early mobilization shortens the out-of-bed period, the length of stay in the ICU, and the total hospitalization time [7]. Typically, phase I of cardiac rehabilitation following cardiac surgery is commenced in the intensive care unit (usually 2–3 days), then is continued in the cardiac surgery department (typically days 2–7). The mobilization of patients after cardiac surgery is complex, due to clinical instability and multi-organ dysfunction. Contributing factors include respiratory insufficiency; impaired cardiovascular system; skeletal muscle weakness; and the effects of medications, especially sedatives. Postoperative recovery and thus, early exercise prescription in patients after cardiac surgery is affected by the presence of many complications: persistent chest pain, shoulder discomfort, anemia, arrhythmias (typically atrial fibrillation), post-thoracotomy syndrome, phrenic nerve injury, sternum instability, delayed wound healing, cognitive dysfunction, sleeplessness, depression, and anxiety [27].

Early mobility in the intensive care unit is contraindicated in the case of [28]:

Absolute contraindications:

- Heart rate < 40 or >120 beats per minute;
- Mean arterial pressure < 60 or >110 mmHg;
- Oxygen saturation < 90%;
- Respiratory rate > 40/min;
- Temperature < 36 or >38.5 degrees Celsius.

Relative contraindications:

- Decreased consciousness;
- Hemoglobin < 7 g/dL;
- Presence of lines if they make mobilization unsafe.

Despite the existence of supporting data for the safety of early mobilization in intensive care units, clinical practice differs, and the amount of rehabilitation offered is often insufficient. This might be because the assessments of health deficiencies are inaccurate. Utilizing existing tools—e.g., the International Classification of Functioning, Disability, and Health—has been strongly recommended for the precise evaluation of the level of cooperation, muscle strength, joint mobility, and functional status (using the Functional Independence Measure, Berg balance scale, Functional Ambulation Categories) prior to the commencement of early mobilization [29]. In the case of uncooperative, critically ill patients, body positioning (every 2 h), passive cycling (Figure 3), joint mobility, passive muscle stretching, and neuromuscular electrical stimulation can be applied [30]. Continuous passive motion prevents contractures and has been used in patients with critical illness and prolonged inactivity [31]. For those who cannot be actively mobilized and with a high risk of soft-tissue contracture—e.g., with some neurological conditions or after trauma—splinting may be recommended. A recent study demonstrated that the early application of daily bedside (initially passive) leg cycling in critically ill patients resulted in improved functional status and improved muscle function at hospital discharge compared to patients who did not receive leg cycling [32].

Neuromuscular electrical stimulation is applied in patients who cannot voluntarily perform muscle contractions to prevent muscle atrophy [33].

In the case of cooperative patients, the mobilization strategy includes transferring in bed, sitting over the edge of the bed, moving from the bed to a chair, standing, marching on the spot, and walking with or without support [34–37].

The Leuven protocol—i.e., the meticulous step-up approach for progressive early mobilization—has been recommended [35]. It includes six levels of mobilization based on cooperation status, assessed by responses to five standardized questions ("open and close eyes", "look at me", "open your mouth and stick out your tongue", "shake yes or no", "I will count to 5, frown your eyebrows afterwards"), cardiorespiratory status, the Berg balance scale, and the Medical Research Council muscle strength scale (Figure 4).

Figure 3. Passive bedside cycling. Source: Reprinted from [35], used with permission.

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
NO COOPERATION S5Q[1] = 0	NOLOW COOPERATION S5Q[1] < 3	MODERATE COOPERATION S5Q[1] 3	CLOSE TO FULL COOPERATION S5Q[1] 4/5	FULL COOPERATION S5Q[1] = 5	FULL COOPERATION S5Q[1] = 5
FAILS BASIC ASSESSMENT[2]	PASSES BASIC ASSESSMENT[3] +	PASSES BASIC ASSESSMENT[3] +	PASSES BASIC ASSESSMENT[3] +	PASSES BASIC ASSESSMENT[3] +	PASSES BASIC ASSESSMENT[3] +
BASIC ASSESSMENT = Cardiorespiratory unstable: MAP < 60mmHg **or** FiO_2 > 60% **or** PaO_2/FiO_2 < 200 **or** RR > 30 bpm Neurologically unstable Acute surgery Temp > 40°C	Neurological or surgical or trauma condition does not allow transfer to chair	Obesity or neurological or surgical or trauma condition does not allow active transfer to chair (even if MRCsum 36)	MRCsum 36 + BBS Sit to stand = 0 + BBS Standing = 0 + BBS Sitting 1	MRCsum 48 + BBS Sit to stand 0 + BBS Standing 0 + BBS Sitting 2	MRCsum 48 + BBS Sit to stand 1 + BBS Standing 2 + BBS Sitting 3
BODY POSITIONING[4] 2hr turning	BODY POSITIONING[4] 2hr turning Fowler's position Splinting	BODY POSITIONING[4] 2hr turning Splinting Upright sitting position in bed Passive transfer bed to chair	BODY POSITIONING[4] 2hr turning Passive transfer bed to chair Sitting out of bed Standing with assist (2 pers)	BODY POSITIONING[4] Active transfer bed to chair Sitting out of bed Standing with assist (1 pers)	BODY POSITIONING[4] Active transfer bed to chair Sitting out of bed Standing
PHYSIOTHERAPY: No treatment	PHYSIOTHERAPY[4] Passive range of motion Passive bed cycling NMES	PHYSIOTHERAPY[4] Passive/Active range of motion Resistance training arms and legs Passive/Active leg and/or cycling in bed or chair NMES	PHYSIOTHERAPY[4] Passive/Active range of motion Resistance training arms and legs Active leg and/or arm cycling in bed or chair NMES ADL	PHYSIOTHERAPY[4] Passive/Active range of motion Resistance training arms and legs Active leg and/or arm cycling in chair or bed Walking (with assistance/frame) NMES ADL	PHYSIOTHERAPY[4] Passive/Active range of motion Resistance training arms and legs Active leg and arm cycling in chair Walking (with assistance) NMES ADL

Figure 4. The Leuven protocol. Abbreviations: BBS—Berg balance scale; MRC—Medical Research Council muscle strength sum scale; S5Q—response to 5 standardized questions for cooperation. Source: Reprinted from [35], used with permission.

S5Q—responses to five standardized questions for cooperation:

- "open and close eyes";
- "look at me";
- "open your mouth and stick out your tongue";
- "shake yes or no";
- "I will count to 5, frown your eyebrows afterwards".

BBS—Berg balance scale:

- Sitting to standing:

  4—able to stand without using hands and stabilize independently;
  3—able to stand independently using hands;
  2—able to stand using hands after several tries;
  1—needs minimal aid to stand or stabilize;
  0—needs moderate or maximal assistance to stand.

- Standing unsupported:

  4—able to stand safely for 2 min;
  3—able to stand for 2 min with supervision;
  2—able to stand for 30 s unsupported;
  1—needs several trials to stand for 30 sec unsupported;
  0—unable to stand for 30 s unsupported.

- Sitting with back unsupported but feet supported on the floor or on a stool:

  4—able to sit safely and securely for 2 min;
  3—able to sit for 2 min under supervision;
  2—able to sit for 30 s;
  1—able to sit for 10 s;
  0—unable to sit without support for 10 s.

MRC (Medical Research Council muscle strength sum scale (0–60):

0—no visible contractions
1—visible contractions/no limb movement;
2—active movement but not against gravity;
3—active movement against gravity;
4—active movement against gravity and resistance;
5—active movement against full resistance,

Max score: 60 (4 limbs, 3 movements per extremity, with a maximum score of 15 points per limb)

Upper extremities: shoulder abduction/elbow flexion/wrist extension.

Lower extremities: hip flexion/knee extension/ankle dorsiflexion.

The authors recommend, as mentioned earlier, the use of the three-staged mobilization model described in Tables 19–21 (A2 and B models).

Table 19. Suggested first stage of early mobilization after cardiac surgery.

Mobilization duration	A2: days 0–2; B: days 0–3
Exercise duration	5–10 min, twice a day
Position of exercises	Supine position, semi-sitting, sitting
Type of exercises	Day 0—after weaning from mechanical ventilator: Respiratory exercises; Effective cough exercises; Percussion. Days 1–2: Exercise applied earlier; Isometric exercises of small muscle groups; Dynamic exercises, initially of small and then of major muscle groups; Inspiratory muscle training; Relaxation exercises.
Activities	Semi-sitting position in bed. Personal care in bed. Transfer to toilet in wheelchair.

Source: Table by authors.

Table 20. Suggested second stage of early mobilization after cardiac surgery.

Mobilization duration	A2: days 2–3; B: days 4–8
Exercise duration	10–15 min twice a day
Position of exercises	Supine position, sitting
Type of exercises	As in stage 1, with an intensity increase—i.e., increased number of repetitions, or at an increased pace, or an increase in the number of sets Dynamic exercises of extremities Coordination exercises Short walks within the room with assistance
Activities	Active sitting over the edge of the bed, standing Personal care in bed

Source: Table by authors.

Table 21. Suggested third stage of early mobilization after cardiac surgery.

Mobilization duration	A2: days 4–8; B: from day 8
Exercise duration	15–20 min twice a day
Position of exercises	Sitting, standing, walking
Type of exercises	As in stage II, but with a gradual intensity increase Inspiratory muscle training Dynamic exercises of major muscle groups Gradual increase in walking distance (continuous or intermittent) Climbing stairs
Activities	Complete mobilization Exercises in sitting and standing position, as well as while walking

Source: Table by authors.

3.4. Home Activity after Hospital Discharge

All eligible cardiac patients should be referred to cardiac rehabilitation after recovery from an acute cardiac event [8]. Notwithstanding that, the referral rate remains insufficient, and motivational strategies to enhance participation in cardiac rehabilitation programs and the provision of comprehensive information about the purposes and formats of cardiac rehabilitation are essential [38,39]. Many patients do not receive sufficient information about the exercise intensities allowed during their post-discharge period at home. Basically, prior to discharge, patients should attain a mobility level of approximately 3 METS, and they should be given a safe and progressive home exercise plan [40]. In some countries—e.g., in England—patients discharged from hospital are contacted by members of a cardiac rehabilitation team in the form of home visits, telephone calls, or outpatient appointments for education/health promotion classes; this period is described as the immediate post-discharge phase [41,42]. Post-discharge activities at home should aim to achieve a gradual increase in functional capacity. Patients are encouraged to walk in and around their homes and then to walk outdoors. Rates of perceived exertion or pulse should be assessed to monitor patients' exercise response. Prior to commencing a supervised exercise program, patients should be able to walk for about 30 min daily. Some specific limitations are imposed temporarily on patients after cardiac surgery. Efforts contraindicated for 12 weeks following cardiac surgery are those against high resistance or with a marked isometric aspect—e.g., lifting or moving heavy items; raising both arms for a long time above the head; and running, swimming, and skiing due to sternum stability concerns [43,44]. Sexual activities can be resumed 1–2 weeks after uncomplicated myocardial infarction without cardiac symptoms during mild to moderate physical activity, and optimally 6-8 weeks after cardiac

surgery (if patients can comfortably walk about 300 m on a flat surface or climb two flights of stairs briskly without chest pain or becoming breathless). Sexual activity is contraindicated in the presence of a low angina threshold and complex ventricular dysrhythmias [45].

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