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Multidisciplinary, early mobility approach to enhance functional independence in patients admitted to a cardiothoracic intensive care unit: a quality improvement programme

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ABSTRACT

Early mobilisation following cardiac surgery is vital for improved patient outcomes, as it has a positive effect on a patient's physical and psychological recovery following surgery. We observed that patients admitted to the cardiothoracic intensive care unit (CTICU) following cardiac surgery had only bed exercises and were confined to bed until the chest tubes were removed, which may have delayed patients achieving functional independence. Therefore, the CTICU team implemented a quality improvement (QI) project aimed at the early mobilisation of patients after cardiac surgery.

A retrospective analysis was undertaken to define the current mobilisation practices in the CTICU. The multidisciplinary team identified various practice gaps and tested several changes that led to the implementation of a successful early mobility programme. The tests were carried out and reported using rapid cycle changes. A model for improvement methodology was used to run the project. The outcomes of the project were analysed using standard 'run chart rules' to detect changes in outcomes over time and Welch's t-test to assess the significance of these outcomes.

This project was implemented in 2015. Patient compliance with early activity and mobilisation gradually reached 95% in 2016 and was sustained over the next 3 years. After the programme was implemented, the mean hours required for initiating out-of-bed-mobilisation was reduced from 22.77 hours to 11.74 hours. Similarly, functional independence measures and intensive care unit mobility scores also showed a statistically significant ($p<0.005$) improvement in patient transfers out of the CTICU.

Implementing an early mobility programme for post-cardiac surgery patients is both safe and feasible. This QI project allowed for early activity and mobilisation, a substantial reduction in the number of hours required for initiating out-of-bed mobilisation following cardiac surgery, and facilitated the achievement of early ambulation and functional milestones in our patients.

INTRODUCTION

Prolonged bed rest after any surgery may contribute to a number of complications.[1–3] Lung infections, pleural effusion, impaired oxygen transport, delirium, deep vein thrombosis and nosocomial infections are the most common complications associated with bed rest.[2 4 5] They may adversely affect functional capacity, activities of daily living, quality of life and increase the rate of hospital readmissions.[1 6 7] However, despite its detrimental effects, bed rest following surgery is still a common practice.[8]

Early mobilisation is a safe, feasible and effective intervention to prevent or mitigate these complications[2 9–14]; however, mobility restrictions are commonly advised for post-cardiac surgery patients to improve overall outcomes.[15–17] Early mobility refers to a mobility programme initiated when a patient has minimal ability to engage in therapy, but with a stable haemodynamic status and acceptable oxygen levels.[18] It effectively improves the cardiorespiratory functions, increasing walking distance at hospital discharge, helping patients attain high functional independence and reducing healthcare use.[10 19–21] Moreover, early mobility interventions have been shown to reduce and prevent pain, pleural effusion, hospital-acquired infections, pressure injuries, blood sugar levels, surgical site infections and delirium, as well as eventually reduce the length of hospital and ICU stays and enhance patient satisfaction.[2 11 22–25] Therefore, the implementation of an early mobility programme may improve a patient's physical and psychological recovery and enhance patients' and their family's engagement and experience.

PROBLEM DESCRIPTION

While early mobilisation has been shown to be both safe and feasible, prolonged bed rest

is still common in ICUs, and we found a similar situation in our cardiothoracic intensive care unit (CTICU) located at a tertiary care cardiac centre.

A baseline survey was conducted by multidisciplinary team members to measure prolonged bed rest to identify mobilisation practices. The survey revealed that patients remained restricted to bed following cardiac surgery until chest tubes had been removed. In addition, patients were only assisted by the assigned nurse to perform bed exercises during this period. There was no standard referral process for physiotherapy, and no standard exercise or mobilisation programme was given to patients.

The maximum functional mobility achieved by the patients in the CTICU was sitting on a chair following the removal of chest drains. The patients achieved an ICU Mobility Scale (IMS)[26 27] score of 5 (transferring from bed to chair) and a functional independence measure (FIM)[28] of 56 on transfer out of the CTICU. IMS is a validated tool for measuring the mobility milestones of patients admitted to the ICU—from bed mobility until ambulation. The FIM measures the level of assistance required for an individual to carry out the activities of daily living.[26–28] Typically, patients were ambulated only on the second postoperative day after transfer to the ward, which may impair a patient's functional independence at the time of discharge, a key element of quality of life. The CTICU team identified this as an improvement area and ran a quality improvement (QI) project to implement early mobilisation in patients following cardiac surgery.

SETTING

The CTICU is a 12-bed unit that serves adult postcardiac surgery patients at Heart Hospital in Doha, Qatar, that performs operations on more than 500 patients per year. The surgeries performed at the hospital include coronary artery bypass grafts (CABGs), valve repair and replacement surgeries, aortic dissection repairs and the implantation of mechanical circulatory devices. Patients from the CTICU are transferred to a high-dependency surgical unit once they are haemodynamically stable without vasoactive support.

RATIONALE

Cardiac surgery is a well-established and frequently performed procedure with excellent outcomes regarding efficacy and safety in cardiac patients.[29 30] However, despite rapid technological advances, cardiac surgery is accompanied by complications that increase mortality and morbidity.[31] A combination of the complexity of the procedure, the use of cardiopulmonary bypass, anaesthesia, surgical incision of the chest, medications and a patient's preoperative health status may all negatively affect various body systems.[32 33] Therefore, supervised exercise programmes are recommended immediately following surgery to limit or prevent these adverse consequences.[2 34] These programmes enhance cardiorespiratory function, improve exercise tolerance and achieve functional milestones earlier with the ultimate aim of improving the patient's quality of life.[2 25] Studies have reported that bed exercises alone are not adequate to prevent postoperative complications in patients after cardiac surgery.[35] Thus, an early activity and mobilisation programme is imperative for postoperative patients.[2 9 34]

AIM STATEMENT

This study aimed to achieve 95% early activity and mobilisation (defined as a gradual increase in activities and mobilisation within 3 hours of extubation) rate following cardiac surgery in patients admitted to the CTICU in our cardiac centre by 30 June 2018.

OBJECTIVES

Our objectives included attaining out-of-bed mobilisation of postsurgical patients admitted to the CTICU within 12 hours of extubation, ensuring patients received a minimum IMS score of 7 on transfer out of CTICU and implementing multidisciplinary, evidence-based activity and mobility practices in the CTICU.

INCLUSION AND EXCLUSION CRITERIA

All patients older than 14 years of age who had undergone CABG, valve repair or replacement surgeries, or aortic dissection repair who were admitted to the CTICU were eligible to be included in the study. Postcardiac surgery patients who required mechanical or circulatory devices to maintain haemodynamic stability (such as intra-aortic balloon pumps, extracorporeal membrane oxygenation and left ventricular assistive device) were excluded. In addition, patients with a Glasgow Coma Scale score below 13, those with limited preoperative mobility (due to stroke, paraplegia, etc) and patients who developed any postoperative complications limiting their normal mobility, for example, stroke or an open sternum, were also excluded from the study.

METHODS

After identifying issues related to mobilisation practices and the benefits of implementing an early mobility programme, a thorough analysis was carried out by the QI task force team, which comprised ICU physicians, nurses and physiotherapists. We adopted the Institute for Healthcare Improvement's collaborative model, which brought together a multidisciplinary team from the CTICU to undertake the project. The team was composed of ICU physicians, cardiac surgeons, physiotherapists, nurses, respiratory therapists, occupational therapists and quality advisors. Early activity and mobilisation were a continuous and coordinated process; thus, the role of the multidisciplinary team was crucial.[36–38] Significant practice gaps were identified during brainstorming and while performing a Pareto analysis (figures 1 and 2).

A model for improvement framework was used to drive continuous improvement. This model recommends

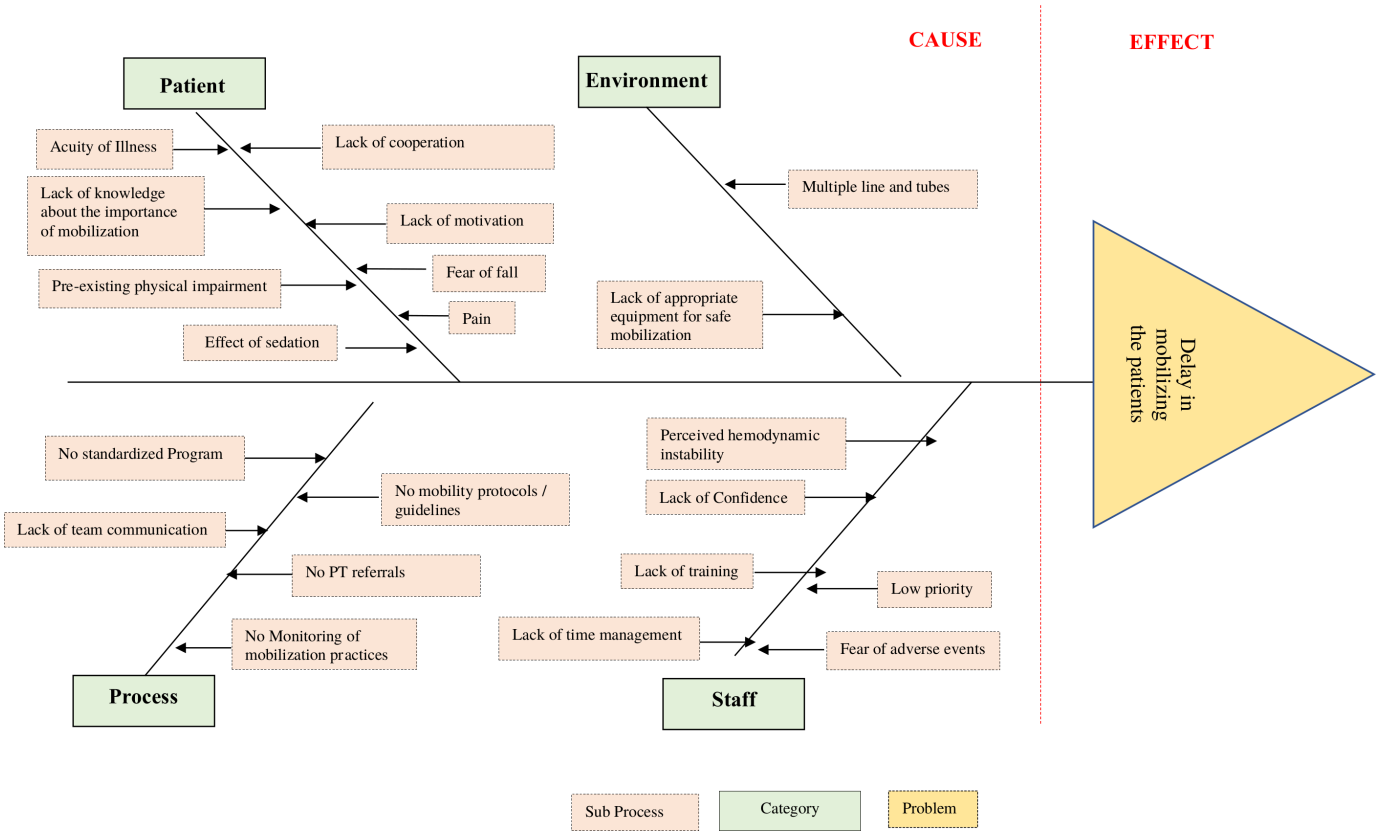

Figure 1 Cause and effect analysis. PT, physiotherapy.

structuring an improvement project by formulating an aim statement, defining measures to understand changes in improvement and an appropriate selection of changes to be tested. Subsequently, Plan–Do–Study–Act (PDSA) cycles were used to test changes.

Changes tested

Several changes were tested in accordance with a Pareto analysis. We introduced evidence-based levels of activity and mobility to ensure the appropriate activity and mobility progression of the patients, which was the first change to be implemented.[21 36 37 39–44] The levels of activity and mobility were based on the number of hours since a patient had been extubated and were formulated via consensus of the MDT and evidence-based practices. The activity and mobility programme were composed of 5 levels, which started from 0 to 3 hours after extubation and lasted until transfer out of CTICU.

To formulate the levels of activity and mobility, regular meetings were conducted. To determine feasibility, ease-of-use and applicability of the activity and

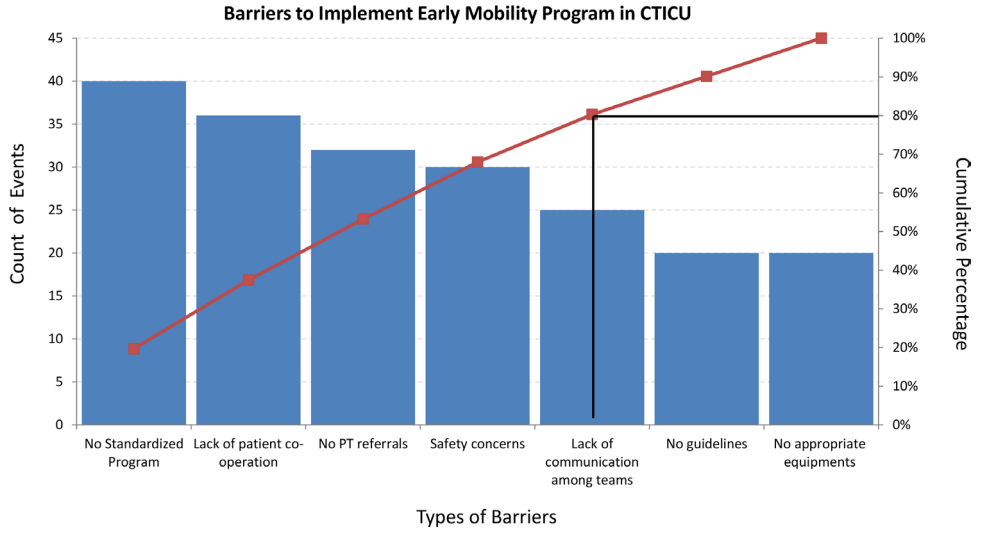

Figure 2 Pareto analysis. PT, physiotherapy.

Table 1 Levels of activity and mobilisation[21 36 37 39–44]

Level	Hours after extubation	Activity and mobilisation programme
1	0 to 3	► Chest physiotherapy. ► Diaphragmatic breathing exercises. – Triflow spirometer. – Active cycle of breathing techniques. ► AROM exercises. ► Progression to chair mode in bed, as tolerated. ► Education on sternotomy precautions. ► Avoid lifting one hand above the head. ► Avoid reaching behind the back. ► Avoid lifting more than 5 kg. ► Avoid pushing and pulling. ► Splinted coughing. ► Avoid long periods of over-the-shoulder activity.
2	three to 6	► Progression with a Triflow spirometer as tolerated ► Continuation of diaphragmatic breathing exercises and active cycle of breathing techniques ► AROM exercises ► Supine to sitting position at the edge of the bed and dangling of the legs ► Feeding in chair-mode position ► Reinforce sternotomy precautions
3	six to 12	► Continuation of chest physiotherapy and AROM exercises ► Sitting at the edge of the bed ► Standing ► Mobilisation out of the bed to the chair
4	12 to 24	► Continuation of chest physiotherapy and AROM exercises ► Ambulation as tolerated, with assistance
5	24 (until transfer to the high dependency surgical unit)	► Continuation of chest physiotherapy and AROM exercises ► Ambulation as tolerated

AROM, active range of motion.

mobility programme, these levels were initially piloted on 4 patients. Table 1 illustrates the levels of activity and mobility. A multi-faceted education programme was provided to all CTICU staff regarding the levels of activity and mobility.

To facilitate mobilisation of all patients at the proper time, especially high-risk patients (those needing multiple vasoactive drug support and patients with ejection fraction less than 40%), a multidisciplinary mobility team (MMbT) comprised of CTICU physicians, a physiotherapist, nurse, respiratory therapist and occupational therapist was formed. This enhanced coordination, collaboration and confidence with the team for the implementation of safe patient mobilisation. Strong leadership support was another vital component of the mobility programme, which was achieved through the early engagement of stakeholders in the programme.

Timely reinforcement of education was also provided. To understand early mobilisation practices and recommendations that have been previously reported, a comprehensive literature review was performed.

PDSA 1: Mobility-level checklist

To ensure compliance with the levels of activity and mobility, an auditing tool was created. A physiotherapist and a nurse from the MDT developed the tool, and feedback was collected from all the members of the MDT. The tool was tested on one patient following extubation and until their transfer to the high-dependency surgical unit. After considering the feedback from the MDT, the tool was further revised, which included detailed components of the levels. Before the revised tool was adopted, it was tested on five more patients. The data collection team's monthly schedule was developed by the MDT, and weekly data monitoring was assigned to the members.

PDSA 2: Initiating physiotherapy referrals

Physiotherapy referrals were initiated for all patients following extubation. However, the referrals were not consistently initiated, which resulted in mobilisation delays. Hence, this change was not adopted.

Instead, all patients were referred to physiotherapy on admission rather than waiting until extubation. This change proved successful, with 100% of the physiotherapy referrals initiated.

PDSA 3: Patient and family engagement

A handbook entitled *A New Life for Your Heart* was prepared by the team, which detailed different type of surgeries and postsurgical care, and highlighted activity and

mobilisation. The booklet was translated into the local language, Arabic, thereby standardising the preoperative education process. The team implemented preoperative educational activities for all surgical patients admitted to the unit. However, this strategy did not work well for patients who underwent surgery as an outpatient, as they were admitted a day before the surgery. To overcome this issue, the team liaised with the outpatient department to ensure all patients scheduled for surgery received preoperative education and the booklet on finalisation of their surgery date.

A questionnaire was also developed to assess each patient's level of understanding regarding the effectiveness of preoperative education. The teach-back method was used to assess the effectiveness of patient education.

PDSA 4: Enhancing the mobilisation experience

It was mandatory to assess pain using the Numerical Rating Scale[45] before initiating the activity and mobilisation programme. This enabled the team to understand the need for pain control measures such as patient-controlled analgesia and ensured that patients were mobilised only with a Numerical Rating Scale score of 3 or below.

PDSA 5: Colour-coded risk categorisation system

To ensure safe activities and mobilisation, a colour-coded risk categorisation system[39 40] was introduced to categorise each patient's risk when performing early activities and mobilisation. Green indicated low risk; yellow represented a potential risk; and red indicated a significant risk. This system enhanced the clinical decision-making process when mobilising patients and helped to prevent potentially adverse events.

PDSA 6: Adopting technology

A cordless telemonitoring system allowed for a wide range of supervised mobilisation activities to take place without hindrance by wires or lines. Moreover, a reclining chair for out-of-bed sitting provided more flexibility in patient positioning, which helped address haemodynamic emergencies such as postural hypotension.

PDSA 7: Preparation of the activity and mobilisation protocol

An evidence-based protocol with a detailed premobilisation assessment and criteria for the initiation and termination of the activity and mobilisation programme was prepared and posted on the hospital's intranet for easy access by all staff.

PDSA 8: Visual reminders

Visual feedback was used to remind staff about the activities and mobilisation patients needed to achieve for each level. For quick reference, a copy of the activity and mobility levels was kept in a patient's file. However, patient files contained many documents, which made these reminders difficult to see. Therefore, this change was abandoned.

Our next change idea involved using a pocket card issued to all of the staff. Unfortunately, the card was not easily visible and tended to be forgotten by the staff. Hence, this change was abandoned.

Finally, the team tried using visual flags. These were attractive, colour-coded flags fixed onto the CTICU cubicle walls near each patient's bed and improved the visibility of the mobility levels. Likewise, their position helped the staff in explaining the level of activity and mobility the patient needed to achieve. This improved mobilisation practices, and the test was adopted.

PDSA 9: Seamless communication of mobility levels

Each patient's level of mobility was conveyed to the staff during multidisciplinary rounds and handovers. As this change ensured adherence to the activity and mobilisation programme, it was adopted.

Display of data

Data collected by the team were placed in run charts, which were displayed in the CTICU QI board. The data were electronically communicated to all members of the MDT. This elevated staff confidence and encouraged them to adhere to the programme.

Continuing education

Continuous in-service education regarding the programme was delivered during unit meetings of the MDT. New staff was trained on the guidelines and protocols of early mobility. Updates on new techniques were addressed through the electronic circulation of recent, relevant articles.

STUDY OF THE INTERVENTIONS

Outcome measures

Each week, the data were retrospectively gathered by a blinded assessor. The outcome measures were the percentage of eligible patients who had progressed according to the levels of activity and mobility, the time of the first out-of-bed mobilisation and the IMS[19 26] and FIM[28] scores that were achieved on transfer to the high-dependency surgical ward.

Process measures

Both qualitative and quantitative methods were used to assess the tested changes. The compliance rates of early mobilisation and each element of the mobilisation were measured. Similarly, the subjective impressions of the front-line staff on the feasibility and success of each of the tested changes was assessed.

Balance measures

The balance measures used in this project were the attainment of functional independence on the fifth postoperative day and adverse events associated with mobilisation. Adverse events were defined as a fall incident, cardiac arrest, new onset of cardiac arrhythmias, accidental removal of invasive lines and tubes, loss of consciousness or hypotension requiring an escalation of inotropes.[46]

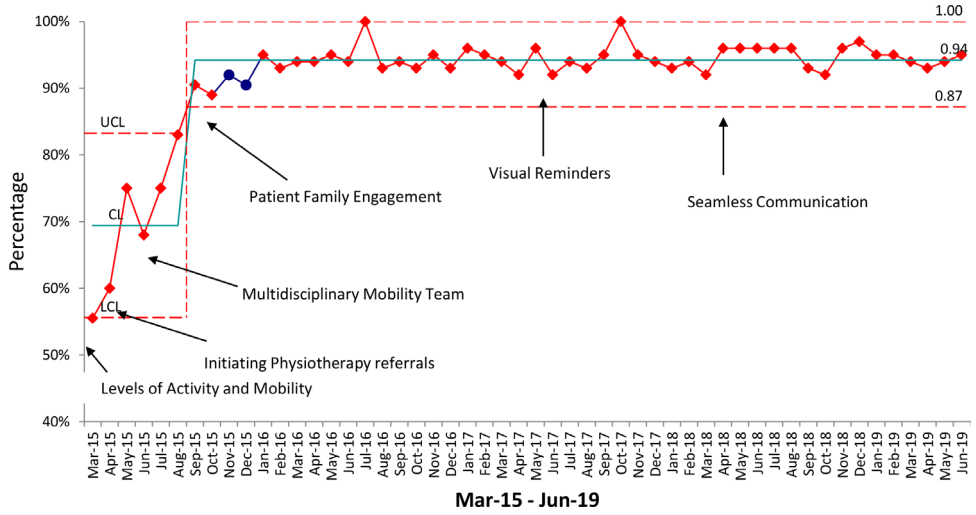

Figure 3 Compliance with the early mobility programme. CL, central line, LCL, lower control limit; UCL, upper control limit;

Statistical analysis

Project outcomes were analysed using standard control chart rules,[47] which detect statistically significant changes in outcomes over time. Each measure was regularly assessed. In addition, we used a preintervention and postintervention analysis using Welch's t-test. The significance of the outcomes was assessed and a p value of <0.05 was considered statistically significant. The charts were generated using QI macros with Excel V.2016.

RESULTS

This programme was implemented in March 2015. There were 1320 participants included in the programme between March 2015 and June 2019.

Primary outcomes

Early mobilisation compliance

The percentage of patients undergoing early mobilisation in March 2015 (following the implementation of the programme) was 55%, which gradually increased to 91% at the end of December 2015. Participation reached 95% by May 2016 and was sustained after that (figure 3).

Out-of-bed mobilisation

The median time of out-of-bed mobilisation preintervention was 23.2 hours, while that for postintervention was 12.3 hours—a 47% reduction (figure 4). Moreover, the mean hours of out-of-bed mobilisation for patients' preintervention was 22.77, which was reduced to 11.74 postintervention, with a variance of 8.13 (p<0.05) (table 2).

FIM and IMS scores

The mean FIM of patients was 54.23 preintervention and 58.62 postintervention (p value=0.00) with improvement observed in the independence of self-care, transfer and locomotion domains. Similarly, the mean IMS score was 3.96 preintervention and 7.23 postintervention (p=0.00), which indicates that the patients began ambulating with

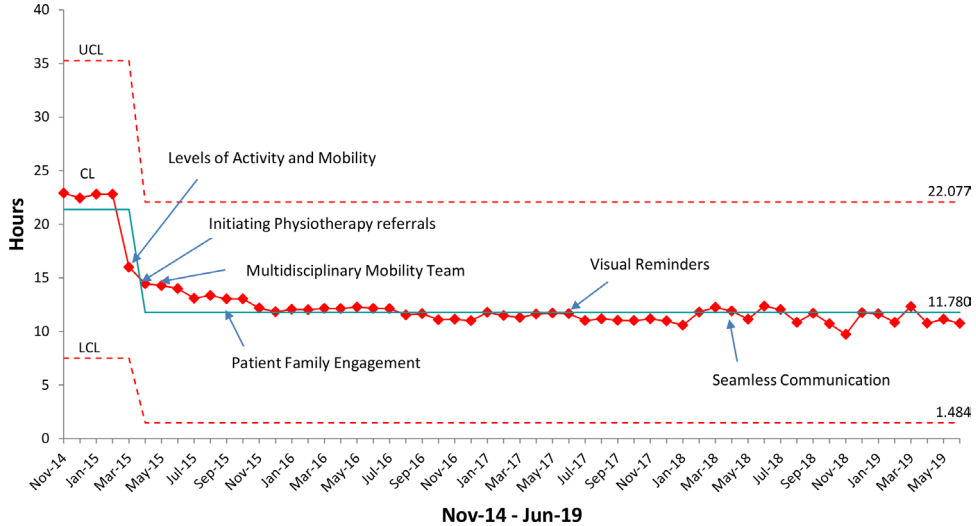

Figure 4 Time taken for out-of-bed mobilisation. CL, central line; IMS, ICU Mobility Scale; LCL, lower control limit; UCL, upper control limit.

Table 2 Mean out-of-bed mobilisation hours, mean FIM and IMS scores

	Out-of-bed mobilisation (hours)		IMS (score)		FIM (score)	
	Pre intervention	Post intervention	Pre intervention	Post intervention	Pre intervention	Post intervention
Mean	22.7	11.74	3.96	7.23	54.23	58.62
Variance	22.49	8.13	0.17	0.56	0.41	0.98
Observations	78	1150	78	1150	78	1150
t value*	20.29		−63.73		−55.96	
P value	0.00		0.00		0.00	

*The t-value was derived from Welch's t-test.
FIM, functional independence measure; IMS, ICU Mobility Scale.

the assistance of two persons at the time of their transfer out of the CTICU following the intervention (table 2).

Balance measures

Adverse events

No adverse events associated with early mobilisation were reported.

Early ambulation

The patients were ambulated 12 hours after extubation, which was lower than the value 48 hours prior to the programme's initiation.

Functional independence at discharge

Patients attained 89% of functional independence as measured on the fifth postoperative day, which is in contrast to the sixth postoperative day prior to the intervention.

DISCUSSION

Since initiating the early activity and mobility programme, there has been a significant improvement in patients' first out-of-bed mobilisation time, as well as improved mobility and functional independence scores on transfer out of CTICU. We achieved a 47% reduction in the time needed for the first out-of-bed mobilisation, while the mean FIM and IMS scores improved from 54.23 to 58.62 and from 3.96 to 7.23, respectively, which demonstrate that the patients were ambulated early and before their transfer out of the CTICU. The time at which ambulation is first initiated in postoperative patients directly affects outcomes.[1 34 48 49]

Understanding barriers when implementing an early mobility programme and formulating strategies to overcome them is one of the key elements of a routine clinical practice.[38] The barriers identified in the CTICU were similar to what have been described in other studies[50–52] and may be categorised as patient-related, structural, ICU culture, and process-related. Patient-related obstacles were the most significant, as they result in patient refusals, lack of motivation, anxiety and patient-perceived illness.[51]

The patient-related barriers identified in this project were lack of patient knowledge and pain. This can negatively affect cooperation, which is essential when implementing early mobilisation. Enhancing patient knowledge regarding the benefits of early mobilisation is a key element in facilitating their engagement.[51 53] Our standardised preoperative education programme and an analysis of its effectiveness ensured that patients received appropriate knowledge. Pain in the sternotomy area and chest tube site was one of the main obstacles to overcome when mobilising patients. Pain limits patient participation and accelerates haemodynamic instability (tachycardia and an increase in blood pressure).[54 55] Therefore, mobilising patients with minimal pain was essential. The strategies undertaken to understand pain intensity and various pain control measures facilitated safety and patient comfort during mobilisation. Related structural barriers were overcome by adopting an evidence-based level of activity and mobility programme, a standardised approach for initiating physiotherapy referrals and incorporating various equipment to facilitate safe mobilisation.

Similarly, cultural barriers were overcome by implementing a multifaceted educational programme for staff, patients and family, and one that involved leadership, setting common goals, conducting regular team meetings, displaying staff appreciations, encouraging a 'no blame' culture and sharing success stories from other QI programmes. Process-related barriers were overcome by enhancing multidisciplinary coordination and communication through daily rounds and checklists, ensuring appropriate documentation, creating a MMbT, defining roles and responsibilities and routine monitoring of the programme. The multidisciplinary rounds and handovers enhanced communication and promoted a collaborative team approach. It also highlighted the barriers experienced during mobilisation and their potential solutions, thereby ensuring the mobilisation of patients at suitable times. While patient safety is a common concern associated with early mobility programmes,[40 56] no adverse events were reported with these activities or mobilisations, which support the evidence that early mobility in the ICU is safe. The colour-coded risk categorisation system, evidence-based protocol and the adoption of technology enhanced the consistency of clinical decisions, safety and ease when performing activities and the mobilisation of patients.

The CTICU QI project included participants at many different ages who had undergone various cardiovascular surgeries such as CABG, valve replacements and

aortic dissections. This indicates that an early mobilisation programme is feasible irrespective of age and type of cardiac surgery. Additionally, this programme may have had a positive influence on reducing hospital-acquired infections. As of June 2019, no catheter-associated urinary tract infections, central-line related blood stream infections or pressure injuries were reported in patients who were included in this project,[57] which increased patient satisfaction.

These factors are also crucial determinants of hospital-stay length. Hence, the project had a profound, although not quantifiable, impact on hospital costs.

Limitations

Despite the significant improvements achieved, this project has some limitations. Since several interventions are tested to improve mobility, we cannot comment which one has the most impact and which one has the least one. In addition, there is no control group; all eligible patients received best practices. The length of stay of the patients in the CTICU was not measured.

Lessons learned

- An evidence-informed QI programme addressing unique barriers is key to creating an early mobility culture.
- Considering patients as essential members of a multidisciplinary team is fundamental for augmenting their participation and overcoming patient-related barriers.
- Good communication and collaboration among a team through multidisciplinary rounds and team meetings are imperative to sustain culture change.
- Including key stakeholders and a multidisciplinary team from the beginning is essential to accomplish and sustain the outcomes of the programme.
- The early mobility programme positively affected patients both physically and psychologically, resulting in improved patient satisfaction and experience.

CONCLUSIONS

The CTICU early mobility programme demonstrated that a well-designed QI process is effective in implementing changes that result in improved patient outcomes. An early mobility programme is safe, feasible and beneficial. The project accomplished the objectives by applying various tests of change based on identified barriers. This project reduced the time to the first out-of-bed mobilisation and facilitated early ambulation, thus improving functional independence in patients. These improvements have been sustained through multidisciplinary staff and patient education, an integrative approach and regular monitoring.

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Contributors PJ led the work and prepared the initial draft of the manuscript. PG served as an Improvement advisor and assisted in data analysis. SS supervised the project and monitored sustainability. AS played a key role in the development of the program. SA contributed to developing the activity and mobility protocol. JM and SV contributed by implementing change ideas and data collection. MV contributed to the preparation of the manuscript and change ideas. GM and MM contributed to protocol development and assessing the outcome measures. DJ contributed to the statistical analysis and interpretation of the data. PJS played a significant role in the preparation of the manuscript and program implementation.

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Disclaimer Institutional review board review was not sought as all of the changes being tested were evidence-based and widely accepted internationally. There was no control group and, therefore, no randomisation so that no patients would be denied of this 'best practice' intervention.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article.

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