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Research Article

Enhanced Recovery After Cardiac Surgery - A Single Tertiary Care Centre Experience in India

Shailendra Kumar Motwani[1]*, Vimal Kant Yadav[2] and Shailesh Jhanwar[1]

[1]Consultant, Cardiac Anesthesiology, Apex Hospital, Jaipur, Rajasthan, India

[2]Consultant, Cardiac Surgery, Apex Hospital, Jaipur, Rajasthan, India

***Corresponding Author**: Shailendra Kumar Motwani, Consultant, Cardiac Anesthesiology, Apex Hospital, Jaipur, Rajasthan, India.

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Abstract

Introduction: The ERAS strategy implies that patients are in the best health for surgery, have evidence based care throughout their hospital stay and have the best possible rehabilitation. They also have the partnership and responsibility for their care.

The implementation of ERAS protocols has improved patient outcomes across various surgical specialities but we are reporting our experience with ERAS protocol for cardiac surgery.

Aims: This retrospective observational study was commenced to assess the impact of ER protocol on

1. The length of stay (ICU stay and Hospital stay).
2. Secondary variables (Extubation time; Time to Spirometry; Time to mobilize; Weaning off inotropes and Removal of invasive lines).
3. The patient experience.
4. Reduced complications and readmissions following cardiac surgery.

Methods: This study included 124 adult patients who underwent cardiac surgery in our tertiary care centre before and after implementation of ER pathway and divided respectively into the CR group and the ER group.

Primary and secondary outcome variables were measured and analyzed. Patients completed a predesigned questionnaire in the post-operative period.

Results: In our experience the time to extubation (60.26 min), time to earlier mobilization and function (mobilize out of bed = 234 min) were significantly less in the ER group leading to more patient satisfaction. There was reduced length of ICU (2.36 days) and hospital stay (6.89 days). At the same time there was earlier weaning off of inotropes (23 ± 1.8 hrs) leading to earlier removal of invasive lines (1.84 days) and all this led to earlier ambulation in the ER group. There was reduced incidence of readmission and complications (AF, ileus, infections) in the ER group.

All the above benefits ultimately led to improved patient and family satisfaction in addition to reduced hospital stay.

Conclusion: The study demonstrated the positive impact of ER pathway in cardiac surgery on the outcomes and patient experience. We are now rolling out ERAS programme to all first time Cardiac surgery patients. We are planning to analyze the financial benefits in the future.

Keywords: *Enhanced Recovery (ER); Conventional Recovery (CR); Cardiac Surgery; Length of Stay; Extubation; Mobilization; Atrial Fibrillation (AF); Ileus; Infection*

Abbreviations

AF: Atrial Fibrillation; ACC: Aortic Cross Clamp; BMI: Body Mass Index; CI: Cardiac Index; COPD: Chronic Obstructive Pulmonary Disease; CPB: Cardiopulmonary Bypass; CR: Conventional Recovery; CABG: Coronary Artery Bypass Grafting; ER: Enhanced Recovery; ICU: Intensive Care Unit; LVEDV: Left Ventricular End Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; PAH: Pulmonary Arterial Hypertension; SVC: Superior Vena Cava; TEE: Transesophageal Echocardiography; TTE: Transthoracic Echocardiography

Introduction

Enhanced recovery after surgery (ERAS) is associated with accelerated recovery and improving outcomes as demonstrated by Professor Kehlet almost 20 years ago [1,2]. Enhanced recovery programmes (ERP) reduce hospital stay and improve outcomes through a structured approach to perioperative care [3]. ERPs effectively reduce the overall complication rates in addition to reducing the hospital stay across various surgical specialties [4]. The implementation of ERAS protocols has improved patient outcomes across various surgical specialities [5] but at the commencement of this pilot there were no other centres in our region reporting to have implemented it for cardiac surgery.

Our approach focused on all aspects of patient care:

- **Pre-operative preparation** aimed at optimizing co-morbidities, discharge planning and patient education.
- **Intra-op focus** was on minimally invasive techniques, tight hemodynamic control with guarded fluid balance (Echocardiography guided), avoidance of long acting anesthetic agents and analgesic planning, meticulous surgical hemostasis from beginning till the end of the procedure.
- **Post-op protocol** was targeted to early extubation; TTE based hemodynamic management, to reduce the opiate analgesia using other agents, rapid mobilization and return to normal diet and function and to encourage more family involvement in patient care.

Although many specialities, including thoracic surgery, have implemented ER pathways mainly based on data from patients undergoing colorectal surgeries [6], the literature favoring the implementation of ER pathways to cardiac surgery is very limited because of the differences in pathophysiology of the disease and various physiological alterations in cardiac surgery (presence of CPB; Aortic cross clamping and cardioplegia and hemodynamoic alterations) so there is a need to develop ER pathways for cardiac surgical patients.

Therefore in order to evaluate the safety and efficacy of the implementation of ER pathways in cardiac surgery, we designed this retrospective observational study comparing CR (Conventional Recovery) group (before implementation of ER pathway) and the ER (Enhanced Recovery) group (after implementation of the ER pathway).

Materials and Methods

After institutional approval, we designed this retrospective observational study in a tertiary care hospital as an aid to quality improvement.

The subjects were assigned into two groups:

- The Conventional Recovery (CR) (n = 61) group (before implementation of the ER pathway).
- The Enhanced Recovery (ER) (n = 63) group (after implementation of the ER pathway).

The ER protocol was based on fast track cardiac surgery principles [6]. This protocol involved all areas of patient care from pre-operative education and optimisation to evidence based perioperative management and early extubation and early functional recovery by a multidisciplinary team with active involvement of the patient and the family.

Fast tracking protocol modified for our centre was applied to the ER group while the CR group underwent recovery with traditional protocol. Patients were asked to fill a pre-designed questionnaire at the time of discharge and grade their level of satisfaction.

Pre-operative Optimisation:
1. Pre - operative assessment and optimization 2. Pre-operative patient education about the events during the hospital stay and written and informed consent. 3. Spirometry training and deep breathing and coughing exercise 4. Detailed pre-operative planning about the course of the patient 5. Reduced pre-operative fasting with carbohydrate rich clear liquids
Perioperative protocol:
1. Short acting anesthetic agents 2. Multimodal analgesia 3. Echo (TEE and TTE) guided fluid and inotrope therapy and hemodynamic management 4. Meticulous surgery and Hemostasis 5. Minimise CPB and Aortic cross clamp duration
Postoperative Care
1. Earliest extubation 2. Adequate multimodal analgesia with regular dose of iv paracetamol and NSAIDS 3. Reduced use of opioids 4. Earliest enteral nutrition 5. Regular use of antacids and gastric motility agents 6. Regular use Ondansetron for first 48 hours postoperatively 7. Syrup Lactulose 15 ml 8 hourly till the gut opens 8. Earliest mobilization (sitting on a chair) and spirometry 9. TTE guided fluid and inotrope therapy 10. Early Weaning off inotropes 11. Early removal of invasive lines, chest drains and urinary catheter

Table 1: *Detailed ER protocol for our centre.*

Statistical analysis

For a confidence level of 95% and confidence interval of 9.85%, a sample size of 50 was calculated using online sample size calculator (Creative Research Systems survey software). For our hypothesis of reducing the hospital stay by at least 2 days with a significance level (alpha) of 0.05 we achieved a power of 80% with a sample size of 50.

So a total 124 adult patients undergoing various cardiac surgeries in a single tertiary care centre were included. Data was collected from June 2017 to October 2017 for the CR group and from November 2017 to February 2018 for the ER group. Data collection was based on review of patient charts and patient care notes. The patients were asked to fill a predesigned survey questionnaire before discharge.

The statistical calculations and t-tests were done using www.quantitativeskills.com/Simple Interactive Statistical Analysis/sisa.

Results

The demographic parameters were comparable between both the groups as shown below.

S. No.	Parameter	Conventional Recovery (CR) (n = 61)	Enhanced Recovery (ER) (n = 63)	p value
1.	Mean age (yrs)	51 ± 16	50.48 ± 13.9	0.176
2.	Male/ Female	31/19	28/22	
3.	BMI	22.14 ± 5.17	22.67 ± 3.7	0.28
4.	LVEF (%)	47 ± 9.5	45 ± 10.20	0.83
5	**Surgeries** Cabg Single valve Double valve Others	 41 (60%) 12 (24%) 6 (12%) ASD (1)/Myxoma (1)	 40 (54.9%) 10 (19.6%) 7 (13.7%) ASD (1) CABG+AVR (3) CABG +CEA (1)	
6.	S. creatinine (pre-op) (> 1.2 mg/dl)	2 (4%)	1 (1.9%)	
7.	Hypertension	20 (40%)	27 (52.9%)	
8.	Diabetes	18 (36%)	22 (43.1%)	
9.	COPD	29 (58%)	26 (50.9%)	
10.	Smoker	26 (52%)	28 (54.9%)	

***Table 2**: Demographic parameters.*

Outcome parameters were as shown below.

S. No.	Parameter	CR group (n = 61)	ER group (n = 63)	p value
1.	Time to extubation after surgery (min)	268.54 ± 16.26	60.26 ± 19.96	0.004
2	Time to start of Spiro (min after surgery)	421.21 ± 31.32	97.51 ± 18.31	0.0002
3.	Time to mobilize out of bed (min after surgery)	699 .83 ± 28.15	234.22 ± 20.76	0.02
4.	Time to start of enteral liquids (min)	476.83 ± 14.55	100.86 ± 10.66	0.02
5	Pt experience (unsatisfied)	9	3	
6.	Length of hospital stay (days)	8.86 ± 0.99	6.89 ± 0.60	0.00057
7.	ICU Stay (days)	5.36 ± 0.64	2.36 ± 0.48	0.029
8	Wean off inotropes (hours)	40 ± 2.3	23 ± 1.8	0.0004
9.	Removal of invasive lines (days)	3.96 ± 0.48	1.84 ± 0.36	0.029
10.	Readmission	8(AF)	3(AF)	
11.	AF	0.18 ± 0.16	0.06 ± 0.12	0.0002
12.	Ileus	0.27 ± 0.48	0.13 ± 0.09	0.06
13.	Infections (Fever; Chest X ray/TLC)	0.17 ± 0.18	0.10 ± 0.02	0.01

***Table 3**: Outcome parameters.*

In our study the various demographic parameters were comparable in both groups with no significant differences.

In our experience the time to extubation (60.26 min), time to start of spirometry (97.51 min), return to enteral liquids (100.86 min) and function (mobilize out of bed = 234 min) were significantly less in the ER group leading to more patient satisfaction. There was reduced length of ICU stay (2.36 days) and hospital stay (6.89 days). At the same time there was earlier weaning off of inotropes (1.47 days) leading to earlier removal of invasive lines (1.84 days) and all this led to earlier ambulation in the ER group. There was reduced incidence of readmission, atrial fibrillation (AF), ileus and infections (esply pulmonary and wound). The main reason for readmission was AF with fast ventricular rate.

All the above benefits ultimately lead to improved patient and family satisfaction (less dissatisfied patients in the ER group) in addition to reduction in the hospital stay.

Discussion

Enhanced recovery after cardiac surgery (ERACS) strategy focuses on all aspects of care for cardiac surgical patients which aims to:

- Optimize the patient pre-operatively for surgery.
- Avoid iatrogenic problems such as postoperative ileus, prolonged ventilation, and prolonged invasive lines.
- Minimize the stress response to surgery.
- Speedy recovery and return to normal function.
- Early recognition of abnormal recovery and intervention if necessary.

The purpose of ER protocol is that patients are in the best health for surgery, have evidence based care throughout their hospital stay and have the best possible rehabilitation [5].

The preoperative optimization and intraoperative management play a key role.

Echocardiography (TTE - pre and postoperatively and TEE- intraoperatively) guided fluid and hemodynamic management plays a key role in improving outcomes in cardiac as well as non-cardiac surgeries. Echocardiography is used to assess the Cardiac output, LV filling (LVEDV), fluid responsiveness (by Doppler across the Aortic outflow tract or Descending thoracic aorta; SVC index) and biventricular function. TEE with a direct visualization of cardiac structures provides important information about the cardiovascular function relevant to hemodynamic management [8].

The patients and their families actively participate and take responsibility for their care (by active communication, incentive spirometry and coughing exercises).

This approach has been used in many centres in the UK for various procedures, especially colorectal and orthopedic surgery, and is now the focus of the Enhanced Recovery Partnership Programme (ERPP) across the UK. There is emerging evidence about the benefits of enhanced recovery, and many other countries are incorporating it into their care; from Denmark, where Professor Kehlet first pioneered the technique, to the USA. The success of ER requires teamwork of all professionals involved in the patients care, including primary care physicians, hospital consultants, allied health professionals and hospital managers [9].

The ER protocol aims to reduce the detrimental effects of surgical stress (increased myocardial oxygen demand, hypoxemia, weakness of respiratory muscles, impaired wound healing and infections) and reduces the metabolic changes that occur [6].

ER is beneficial for both the patient and the health care service as a whole. Patients are prepared for surgery and medically optimized. In hospital, the patients receive evidence based care and recover more quickly. Pain, postoperative bowel dysfunction and immobilization are minimized. All this results in reduced hospital stay and therefore fewer complications and hospital associated infections. The patients are able to return to their usual activities, including work, more quickly.

Significant reductions in median length of stay have been achieved, which could lead to an estimated 140,000 - 200,000 patient bed days saved throughout the UK per year [5].

The enhanced efficiency of ERACS is continued after discharge and minor complications are treated by a ward visit without the need for an overnight stay. Therefore, although re-admission rates may not necessarily drop, the overall time spent in hospital is reduced and there is no evidence of an increase in the rate of serious complications.

A recent meta-analysis of enhanced recovery programmes in colorectal surgery concluded that this approach reduced the length of hospital stay and the number of complications without compromising patient safety [10].

The ER pathway requires an integrated team approach by all the professionals involved in patient care starting from admission to safe discharge of the patient from the hospital.

Early extubation in our experience improves outcomes as demonstrated by Goeddel Lee A., *et al.* [11]. Harris KC., *et al.* demonstrated that early extubation in congenital cardiac surgery was associated with lower morbidity and shorter lengths of intensive care unit and hospital stays [12].

Kandasamy A., *et al.* proved that early extubation with adequate perioperative optimisation (shorter ACC and CPB times, absence of arrhythmias, absence of severe PAH) is possible and safe in valvular heart surgery and results in faster recovery, shorter ICU and hospital stay with no significant difference in postoperative patient outcomes [13].

We demonstrated that early mobilization and return to normal diet and function lead to improved postoperative outcomes.

Weimann A., *et al.* recommended the key aspects of perioperative care from a nutritional and metabolic point of view (including early ambulation, reduced fasting periods and reduced use of paralytic agents on ventilator) and included them in the ERAS pathway [14].

In our experience the patients in the Enhanced Recovery group were more satisfied.

The clinician and patient partnership for care improves the experience of patients going through these pathways. Increased functional capacity for patients occurs due to the shorter time spent in hospital, reducing waiting times or reducing the number of staff required, which has secondary financial benefits to the health care service and to the hospitals at a local level [15].

Perkins A., *et al.* in 2013 with the help of a questionnaire in more than 50 patients demonstrated that the adoption of the ERAS programme in cardiac surgical patients is safe and practical with high levels of patient satisfaction. They stressed on the fact that patient motivation and engagement is essential [16].

Although the incidence of postoperative pain was not assessed in our study but the patients in ER group reported less severe pain as compared to CR group. This may be due to enhanced functional recovery and a psychological impact of early ambulation.

In our experience ERACS programme was associated with reduced hospital and ICU length of stay.

Costello C., *et al.* in a pilot study of 155 patients undergoing CABG surgery have shown that ERAS pathway is associated with reduced ICU and hospital stay and improved patient satisfaction along with reduced incidence of AF and postoperative pain and nausea scores [17].

Early ambulation due to ERACS protocol is associated with reduced complications. This has been demonstrated by Valerie A., *et al* [18].

WJ Fawcett showed that enhanced survival, with improved quality of life, for patients with and without cancer, should be seen as the ultimate reward for all patients within ER programmes [19].

ERAS pathways encompass the entire perioperative period. Individually, they have been demonstrated to improve outcome. In addition, they engage patients in their care and recovery. Although many of the interventions are well established, others require further study to clarify their role in improving postoperative outcomes [20].

In our experience the inotropes were weaned off early in the ER group and this resulted in earlier removal of invasive line which ultimately contributed to early ambulation and thus enhanced recovery.

Hamilton., *et al.* in a retrospective study of 50 consecutive pediatric cardiac surgeries demonstrated significant differences in the hospital stay and lower inotrope scores in the early-extubation group (14.89 vs 31.68, $P < .0001$). The reintubation rate was not significant. EE patients had equivalent hemodynamic profiles shown by a decreased necessity for inotropic support. They concluded that early extubation is feasible in low/medium-risk pediatric congenital heart surgery patients [21].

In our experience ER pathway was associated with reduced rates of readmission.

Hardman., *et al.* in a study of 37 patients in 2014 demonstrated that ERAS programme in cardiac surgery is safe and there is no increase in complication or readmission rates [2].

Paton F., *et al.* in a database search from 1990 to 2013 assessed the impact of enhanced recovery programmes in UK and concluded that ER programmes are associated with reduced hospital stay without increasing the readmission rates [22].

Wood T., *et al.* in a prospective analysis of 2876 patients undergoing colorectal surgeries in 15 academic hospitals demonstrated that following colorectal surgery using an ERAS pathway, shortened length of stay was not associated with an increased return to the ER or hospital readmission. The majority of return visits to the hospital were ER visits not requiring readmission and the predominant reason for return were surgical site infections and wound complication [23].

In our study ERACS was associated with reduced incidence of AF, ileus and infections.

Fleming., *et al.* in a prospective observational study in 105 patients undergoing cardiac surgery in a teaching hospital demonstrated that there was a significantly reduced incidence of postoperative complications(hospital acquired infections, AF, Acute kidney injury, postoperative myocardial infarction, respiratory failure and death) n in the ERAS group [24].

In a report by Health Partners and Regions Hospital, early removal from ventilator after heart surgery was associated with improved care, lower medical costs and reduced risk of infection and reduced need for ICU care.

Soltis Lisa., *et al.* in a study of 12 ICU and 41 intermediate care cardiothoracic patients showed that early extubation is associated with reduced pulmonary complications which ultimately leads to decreased returns to ICU in addition to decreased length of stay and decreased hospital costs [25].

Liang Li., *et al*. in a single center cohort of 254 patients undergoing colorectal surgery suggested that enhanced recovery protocols were associated with reduced surgical site infections, reduced overall postoperative complication rate in addition to reduced hospital stay and reduced costs [26].

Paton F., *et al*. in a rapid evidence synthesis from eight databases showed a consistent evidence that enhanced recovery programs can reduce length of patient hospital stay without increasing readmission rates [22].

Gelijns AC., *et al*. in a prospective study involving 5158 patients found that intubation time of 24 - 48 hours (HR 1.49; CI 1.04 - 2.14) and ventilation > 48 hours (HR 2.45; CI 1.66 - 3.63) were associated with increased risk of postoperative infection and readmission risk [27].

Valerie A., *et al*. also demonstrated that a team based approach for early ambulation is associated with reduced incidence of postoperative ileus [18].

Limitations of the Study

1. Propensity scoring was not done because cardiac surgical population is usually homogenous and there are usually no statistically significant differences.
2. Financial benefit was not evaluated.
3. Smaller sample size.
4. Single centre study.
5. Further studies are needed to evaluate long term quality of life of postoperative patients undergoing surgery under the ER pathway.

Conclusion

Our study demonstrated that enhanced recovery in cardiac surgery (ER) is safe; with no increase in readmission or complication rates and a significantly reduced ICU and hospital length of stay. This increased capacity associated with enhanced recovery has positive implications on patient experience and efficient utilization of valuable hospital resources. We will analyze the financial benefits in the future.

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