Recovery Pattern in Different Surgical Approaches on Thoracic Enhanced Recovery based Fourteen-Step Protocol in Patients Undergoing Cardio-thoracic Surgery at University Hospital of Nepal

Karmacharya RM,[1]Shakya R,[2]Singh AK,[1]Baidya S,[2]Dahal S,[1]Dhakal P,[1]Shrestha P,[1]Bhandari N[1]

[1]Department of Surgery (Cardio Thoracic and Vascular),

[2]Department of Physiotherapy,

Dhulikhel Hospital, Kathmandu University Hospital

Kathmandu University School of Medical Sciences

Dhulikhel, Kavre, Nepal.

Corresponding Author

Robin Man Karmacharya

Department of Surgery (Cardio Thoracic and Vascular),

Dhulikhel Hospital, Kathmandu University Hospital

Kathmandu University School of Medical Sciences

Dhulikhel, Kavre, Nepal.

E-mail: reachrobin773@hotmail.com

Citation

Karmacharya RM, Shakya R, Singh AK, Baidya S, Dahal S, Dhakal P, et al. Recovery Pattern in Different Surgical Approaches on Thoracic Enhanced Recovery based Fourteen-Step Protocol in Patients Undergoing Cardio Thoracic Surgery at University Hospital of Nepal. *Kathmandu Univ Med J.* **Online First.**

ABSTRACT

Background

Cardio-thoracic surgery involves open and minimally invasive techniques. Enhanced recovery after surgery is used for early recovery from surgery. Enhanced recovery after surgery decreases hospital stay duration. Patients undergoing Enhanced recovery after surgery after video assisted thoracic surgery use less pain killers and have less hospital cost. There has not been any study on outcomes on patient who follow physiotherapy protocol designed in our setting.

Objective

To find the physiotherapy outcomes in patients undergoing thoracic enhanced recovery after surgery (T-ERAS) based 14 step protocol locally designed at Dhulikhel Hospital, Kathmandu University Hospital (DH, KUH).

Method

This is a retrospective cross sectional observational study. All the cases who underwent cardiothoracic surgery were classified based on the approach of chest surgery performed into groups Sternotomy, Thoracotomy and Video Assisted Thoracic Surgery (VATS) groups. Patients were advised for Thoracic Enhanced recovery after surgery based on the protocol that has been devised at Dhulikhel Hospital. The recovery of patients based on activities they could perform was noted and analyzed.

Result

Both ICU stay and hospital stay in number of days were highest in thoracotomy (6.04 days) group while that was lowest in video assisted thoracic surgery group (1.67 days). There is a similar recovery until step 5, i.e. 2 days and rapid progression in further steps in video assisted thoracic surgery group while it is much slower in both sternotomy and thoracotomy groups.

Conclusion

Postoperative mobilization and physiotherapy enhance early healing and decrease hospital stay. Mean hospital stay and ICU stay were shorter for video assisted thoracic surgery cases compared to Thoracotomy and Sternotomy groups and the mean days to achieve different steps varied within the protocol between groups compared.

KEY WORDS

Cardio-thoracic surgery, Physiotherapy, Protocol, Sternotomy, Thoracic enhanced recovery after surgery, Thoracotomy, Video assisted thoracic surgery

INTRODUCTION

Cardio-thoracic surgery involves open and minimally invasive surgery of heart and lung using surgical approaches like Video Assisted Thoracoscopic Surgery, Sternotomy, Minithoracotomy and Thoracotomy.[1] Cardiac surgery can range from open and closed heart surgery for a variety of cardiac anomalies. Thoracic surgery commonly performed are decortication for empyema, pleural biopsy, pleurodesis, lobectomy, pneumonectomy etc. The morbidity to surgery varies between the open and minimally invasive surgery where the surgery related trauma and morbidity is higher for open surgery.[2]

Application of perioperative protocols known as Enhanced recovery after surgery (ERAS) protocols uses early mobilization during postoperative period for early recovery after surgery. This approach when applied to patients who went lung cancer surgery were found to have significantly lower morbidity rate.[3] Several studies done showing the use of thoracic enhanced recovery protocols of their own have shown improvement in outcomes like length of stay, complications rate or readmission rate.[3-5] The patients undergoing ERAS after Video Assisted Thoracic Surgery (VATS) VATS showed significant reduction of postoperative morphine equivalents, total fluid balance and mean inflation adjusted hospital cost.[5]

In this study, we tested the outcomes such as ICU admission days, ventilator in patients undergoing Thoracic Enhanced Recovery After Surgery (T-ERAS) based protocol locally designed at Dhulikhel Hospital, Kathmandu University Hospital (DH, KUTH). The aim of this protocol is to adhere to early physiotherapy and mobilization following cardio thoracic surgery.

METHODS

We did a retrospective study taking data from Dhulikhel Hospital patient records. We included all the cases who underwent cardiothoracic surgery and were admitted to the ICU at Dhulikhel Hospital, Department of Surgery during January 2016 to December 2018. We classified the cases on the basis of the approach of chest surgery performed into groups Sternotomy, Thoracotomy and Video assisted thoracic surgery (VATS). If VATS cases were converted to thoracotomy we included them in the thoracotomy group. In Sternotomy, midline incision is given and full sternotomy is done. For thoracotomy, intercostal incision is longer than 5 cm and rib spreader is used. While in case of VATS, all intercostal incisions are smaller than 5 cm and laparoscopic instruments are used. During analysis we included cases done by VATS as minimally invasive and that by Thoracotomy and Sternotomy as invasive surgical technique.

All eligible patients were advised for T-ERAS based on the protocol that has been devised at Dhulikhel Hospital. The protocol included preoperative chest physiotherapy for a week, smoking cessation for two weeks prior to surgery and 14 steps postoperative physiotherapy protocol (Table 1). The patient is advised progress on this fourteen steps as much as possible and the days taken to attain the different steps were noted as soon as the patient is able to perform them.

The hospital record data was analyzed using Statistical Package for the Social Sciences (SPSS) 20.0.

Table 1. Fourteen step protocol

Steps	Activities	Date achieved
1	Passive Range of motion (ROM), active ankle exercise, self feeding, sitting on bed.	
2	Same+Lung expansion exercise (deep breathing+deep diaphragmatic+segmental breathing), Incentive Spirometer, Dangling of legs at the side of bed	
3	Same+active assisted ROM sitting in bed (arm flexion), moving within bed with splinting. Transfer to chair, Standing with marching on spot.	
4	Same+Minimal resistance ROM, arm flexion upto full ROM, sit ups, increased sitting time, transfer to chair twice daily.	
5	Same+Moderate resistance ROM exercise upto full ROM, sit ups and lunges	
6	Same+standing and regular activities, trunk extension, walking to bathroom	
7	Same + standing aerobic exercise; Walking 10 feet at comfortable pace with pacing	
8	Same + increased ambulation (hall ambulation 30 feet / as tolerated 3-4 times/day)	
9	Increase program, energy conservation. Walk downstairs and use elevators for going up.	
10	Walking with light weight - increased walking distance	
11	Increase duration of each activity, teach self monitoring with pulse rate, walking distance 70 feet.	
12	Resistance exercise for limbs Walking downstairs to 2 flights	
13	Independent hall ambulation 100 feet.	
14	Walk up 1 flight of stairs up and down	

RESULTS

There were 48 patients during the time frame. Of these, 33 (68.8%) were male and 15 (31.2%) were female. Of these, 26 (54.17%) underwent thoracotomy, 12(25%) underwent VATS while 10 (20.83%) had surgery by sternotomy approach (Table 2).

Table 3 shows mean ICU stay and hospital admission days in different surgical approaches. Both ICU stay and hospital stay were highest in thoracotomy group and lowest in VATS group.

Table 2. Number and percentage of cases in different surgical approaches.

Approach	Number	Percentage
Thoracotomy	26	54.17
Sternotomy	10	20.83
VATS	12	25
Total	48	100

Table 3. Mean ICU stay days and hospital admission days in different surgical approaches.

Approach	ICU Stay	Hospital Stay
Thoracotomy	6.04	11.38
Sternotomy	5	7.4
VATS	1.67	5.83
Total	48	100

The findings were statistically significant ($p < 0.05$) in both ICU stay and Hospital stay. For post hoc tests in ICU stay, it was significantly higher in thoracotomy vs VATS and Sternotomy vs VATS. In hospital stay, no significant difference between the two groups was noted on post hoc tests.

Figure 1 shows mean days required to attain consecutive steps from 14 step protocol in the three approaches. In all the groups, mean days required is within two days till step 5. Then after step 6 there is rapid progress to further steps for VATS group while it is much slower for sternotomy and thoracotomy groups.

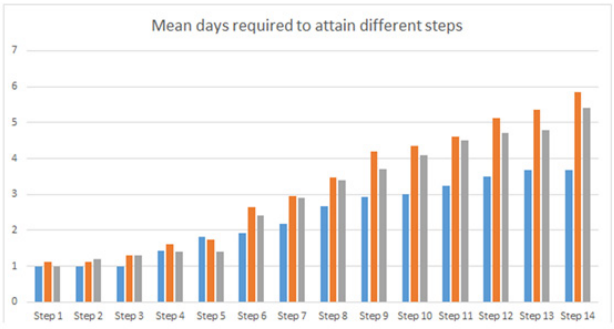

Figure 1. Mean days required to attain different steps in 14 step protocol in different approaches

In figure 2, similar graph is drawn but the groups thoracotomy and sternotomy are mixed as invasive approach and VATS kept as minimally invasive approach. The rapid progression from step 6 can be seen here as well.

Figure 3 shows Kaplan Meier Curves for invasive and minimally invasive approach for reaching steps 8 to 11. The gaps in the curve of two approaches in step 8 and step 9-11 can be noted. Figure 4 shows the curve for reaching step 14. After day 4 there is much difference in proportion of cases reaching step 14. The p value between two curves was less than 0.01.

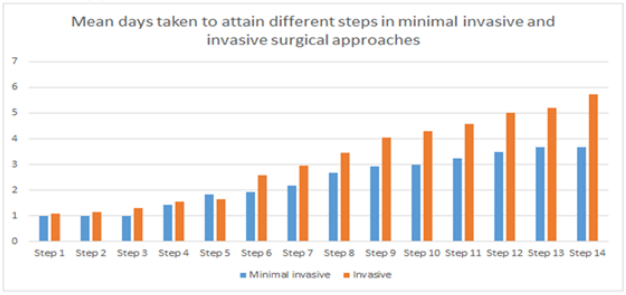

Figure 2. Mean days taken to attain different steps in minimally invasive and invasive approaches

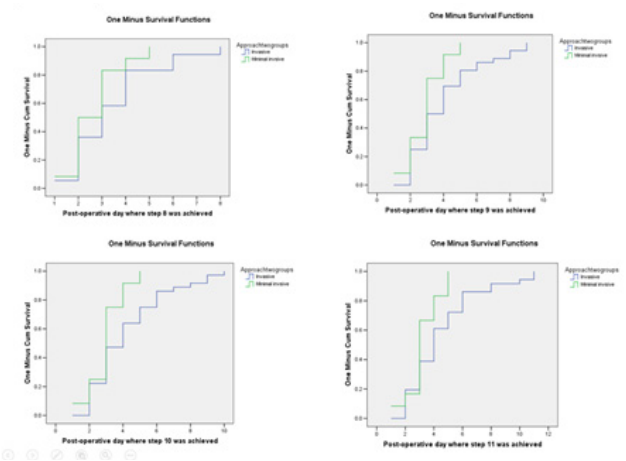

Figure 3. Kaplan-Meier Survival Curve for 8th to 11th Step

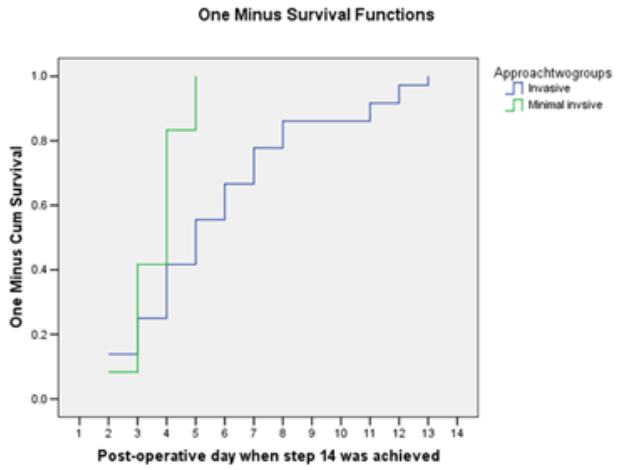

Figure 4. Kaplan Meier Curves for steps 14

In table 4, mean days taken to attain different steps between minimally invasive and invasive approaches are shown. Statistical significance ($p < 0.05$) can be noted in step 3, 6, 7, 10 to 14. The mean number of days taken to reach step 1 to 5 (except step 3) is not significantly different in two approaches but there is significantly different in most of the steps from step 6 onwards. There is lesser days taken to attain the steps in minimally invasive approach in all the steps except step 5. An important "big jump" in the days taken can be noted in step 6 of invasive approach in which there is 2.58 days in step 6 while 1.64 in step 5 (marked bold in the table).

Table 4. **Two approach Vs steps 1-14**

	Minimally Invasive	Invasive	
	Mean days to achieve	Mean days to achieve	p value
Step 1	1	1.0833	0.32
Step 2	1	1.14	0.13
Step 3	1	1.31	< 0.05
Step 4	1.42	1.56	0.46
Step 5	1.83	1.64	0.28
Step 6	1.92	2.58	< 0.05
Step 7	2.17	2.94	< 0.05
Step 8	2.67	3.44	0.07
Step 9	2.92	4.06	0.19
Step 10	3	4.28	< 0.05
Step 11	3.25	4.58	< 0.05
Step 12	3.5	5	< 0.05
Step 13	3.67	5.19	< 0.05
Step 14	3.67	5.72	< 0.05

DISCUSSION

Many surgical techniques for thorax surgery have been developed from large incisions, keyhole approaches to robotic surgical approach. For cardiac surgeries, minimally invasive techniques like minithoracotomy, hemisternotomy are getting popular compared to standard sternotomy technique.[6] For lung's surgery, shift is from posterolateral incisions, muscle sparing thoracotomy to VATS. Now keyhole surgeries for thorax have developed as single port VATS and Robot assisted thoracoscopic surgery (RATS).[2] Newer approach includes subxiphoid approach for thorax surgeries.[7] These minimally invasive techniques help in quicker recovery and less hospital stay of patients which match our findings.[8]

ERAS protocol is set to increase the quality of recovery of patients and duration of hospital stay after surgery.[9-12] In postoperative management, early mobilization within 24 hours and physiotherapy are essential tools for faster recovery.[13] Inability to mobilize early delays discharge of patients.[14] Physiotherapy helps in recovery from postoperative respiratory insufficiency, improves respiratory function and prevents complications like atelectasis, pneumonia, empyema and Deep Vein Thrombosis.[15] Pulmonary physiotherapy before and after thoracic surgery improves exercise capacity and quality of life.[16] Postoperative physiotherapist supervised physical activity improves postoperative functional capacity and reduces the length of hospital stay.[17]

There are many locally followed physiotherapy protocols chiefly focusing on pulmonary physiotherapy and mobilization for post cardio thoracic surgery cases. Hourly deep breathing exercises with or without a Positive Expiratory Pressure (PEP), deep breathing exercises, coughing techniques, chest wall vibrations and mobilization focused on the initial five postoperative days with one to six treatment sessions per day, mobilization done from sitting to standing or positioning to sides, bilateral upper extremity exercises are done in different places.[18,19] A program comparison showed no difference between expiratory and inspiratory stimulating techniques applying early mobilization in both groups for cardiac rehabilitation.[20] We developed a physiotherapy protocol for recovery after cardiothoracic surgery which includes patients achieving various steps of physiotherapy.

In our protocol, pulmonary physiotherapy along with passive progression to active mobilization was divided into 14 steps with endpoint of patient being able to walk a flight of stairs up and down. Early sitting position and mobilization (walking within four hours) leads to better recovery compared to that done on the next day.[21] A seven step protocol was used to assess the evolution of physical therapy in patients after cardiac surgery until hospital discharge. Pulmonary physiotherapy including deep diaphragmatic exercises and incentive spirometry were similar to ours.[22] In a study from India, pulmonary rehabilitation and range of motion exercise of extremities were done in cases recovering from thoracic surgery from day one which is similar to our protocol. Dangling of lower limbs over edge of the bed was done in day one, walking up to chair and sit to stand exercises in day two and staircase climbing by day four.[23] In our study, we noted differences in minimally invasive and invasive approaches after step 6. As walking is commenced from step 6, postoperative pain in invasive approach might have limited progression from this step onwards. 39.9% patient could do ambulation by second postoperative day following cardiac surgery.[22] VATS lobectomy developed less pulmonary complications and were mobile earlier than thoracotomy lobectomy.[24] Wenger protocol devised a 14 steps protocol for cardiac rehabilitation in post myocardial infarction cases focusing on mobilization, ambulation is started in 2-3 days.[25] They haven't mentioned pulmonary physiotherapy in their work.[25]

We could not find relevant similar physiotherapy protocol in our context. We could not find adequate literature comparing outcomes in different approaches of cardiothoracic surgery relating to postoperative physiotherapy goals.

CONCLUSION

Postoperative mobilization and physiotherapy enhance early healing and decrease hospital stay. Mean hospital stay and ICU stay were shorter for VATS cases compared to Thoracotomy and Sternotomy groups. The mean days to achieve different steps varied within the protocol with steps 3,6,7,10-14 being earlier in minimally invasive group

compared to invasive group. In step 14, the proportion of cases where this step is attained in groups minimally invasive and invasive is similar till 4th day after which there is huge gap in two groups with longer duration for invasive group.

ACKNOWLEDGEMENT

We would like to extend our thanks to the Department of Surgery, Cardiac ICU, Medical ICU and Department of Physiotherapy, Dhulikhel Hospital for their support.

REFERENCES

1. Zahid I, Nagendran M, Routledge T, Scarci M. Comparison of video-assisted thoracoscopic surgery and open surgery in the management of primary empyema. *Curr. Opin. Pulm.* 2011;. 17: 255–9.
2. Wong MKH, Sit AKY, Au TWK. Minimally invasive thoracic surgery: beyond surgical access. *J. Thorac. Dis.* 2018;10:1884.
3. Mayor MA, Khandhar SJ, Chandy J, Fernando HC. Implementing a thoracic enhanced recovery with ambulation after surgery program: key aspects and challenges. *J. Thorac. Dis.* 2018;10: 3809–14.
4. Muehling BM, Halter GL, Schelzig H, Meierhenrch R, Steffen P, Plassmann LS, Orend KH. Reduction of postoperative pulmonary complications after lung surgery using a fast track clinical pathway. *Eur. J. Cardiothorac. Surg.* 2008; 34: 174–80.
5. Martin LW et al. Implementing a Thoracic Enhanced Recovery Program: Lessons Learned in the First Year. *Ann. Thorac. Surg*. 2018; 105: 1597–1604.
6. Doenst T, Diab M, Sponholz C, Bauer M, Färber G. The Opportunities and Limitations of Minimally Invasive Cardiac Surgery. *Dtsch. Arztebl. Int*. 2017; 114:777–84.
7. Suda T, Hachimaru A, Tochii D, Maeda R, Tochii S, Takagi Y. Video-assisted thoracoscopic thymectomy versus subxiphoid single-port thymectomy: initial results. *Eur J Cardiothorac Surg*. 2016; 49:54–8.
8. Dieberg G, Smart NA, King N. Minimally invasive cardiac surgery: A systematic review and meta-analysis. *Int J Cardiol.* 2016; 223: 554–60.
9. Ljungqvist O, Scott M, Fearon KC. Enhanced Recovery After Surgery: A Review. *JAMA Surg.* 2017; 152: 292–8.
10. Wang WK, Tu CY, Shao CX, Chen W, Zhou QY, Zhu JD, et al. Impact of enhanced recovery after surgery on postoperative rehabilitation, inflammation, and immunity in gastric carcinoma patients: a randomized clinical trial. *Brazilian journal of medical and biological research.* 2019; 52: 8265.
11. Shang Y, Guo C, Zhang D. Modified enhanced recovery after surgery protocols are beneficial for postoperative recovery for patients undergoing emergency surgery for obstructive colorectal cancer. *Medicine*. 2018; 97: 12348.
12. Brown JK, Singh K, Dumitru R, Chan E, Kim MP. The Benefits of Enhanced Recovery After Surgery Programs and Their Application in Cardiothoracic Surgery. *Methodist Debakey Cardiovasc J.* 2018; 14: 77–88.
13. Medbery RL, Fernandez FG, Khullar OV. ERAS and patient reported outcomes in thoracic surgery: a review of current data. *J. Thorac. Dis.* 2019; 11: 976–86.
14. Smart NJ, White P, Allison AS, Ockrim JB, Kennedy RH, Francis NK. Deviation and failure of enhanced recovery after surgery following laparoscopic colorectal surgery: early prediction model. *Colorectal Dis*. 2012;14: 727–34.
15. Goñi-Viguria R, Yoldi-Arzoz E, Casajús-Sola L, Aquerreta-Larraya T, Fernández-Sangil P, Guzmán-Unamuno E, Moyano-Berardo BM. Respiratory physiotherapy in intensive care unit: Bibliographic review. *Enferm Intensiva.* 2018;29(4):168–81.
16. Vagvolgyi A, Rozgonyi Z, Kerti M, Vadasz P, Varga J. Effectiveness of perioperative pulmonary rehabilitation in thoracic surgery. *J. Thorac. Dis.* 2017;9: 1584–91.
17. Mungovan S, Singh P, Gass G, Smart N, Hirschhorn A. Effect of physical activity in the first five days after cardiac surgery. *Journal of Rehabilitation Medicine.* 2017; 49: 71–7.
18. Westerdahl E, Olsén MF. Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden -a national survey of practice. *Monaldi Arch. Chest Dis.* 2011; 75: 112–9.
19. Westerdahl E. Physical Therapy Treatment after Cardiac Surgery: A National Survey of Practice in Greece. *Journal of Clinical & Experimental Cardiology.* 2013; 7: 1–5.
20. Pulmane D, Vetra A, Lacis R, Driba D. Physiotherapy following cardiac surgery: Program comparison. SHS Web of Conferences 2018; 40: 2012.
21. Kaneda H, Saito Y, Okamoto M, Maniwa T, Minami K, Imamura H. Early postoperative mobilization with walking at 4 hours after lobectomy in lung cancer patients. *Gen Thorac Cardiovasc Surg.* 2007; 55: 493–8.
22. Winkelmann ER, Dallazen F, Bronzatti ABS, Lorenzoni JCW, Windmöller P. Analysis of steps adapted protocol in cardiac rehabilitation in the hospital phase. *Rev. Bras. Cir. Cardiovasc.* 2015; 30: 40–8.
23. Sultanpuram S, Alaparthi GK, Krishnakumar SK, Ottayil ZCP. Physiotherapy Practice Patterns for Management of Patients Undergoing Thoracic Surgeries in India: A Survey. *Surg Res Pract.* 2016; 9717489.
24. Agostini P, Lugg ST, Adams K, Vartsaba N, Kalkat MS, Rajesh PB, et al. Postoperative pulmonary complications and rehabilitation requirements following lobectomy: a propensity score matched study of patients undergoing video-assisted thoracoscopic surgery versus thoracotomy. Interact. *Cardiovasc. Thorac. Surg.* 2017; 24: 931–7.
25. Bartels MN. Cardiac Rehabilitation. Essential Physical Medicine and Rehabilitation 2006; 119–45.