Economic Impact of an Enhanced Recovery Pathway for Lung Resection

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Background. **Multimodal enhanced recovery pathways (ERP) improve clinical outcomes and hospital length of stay for patients undergoing lung resection. However, data supporting their economic impact is lacking. This study evaluated the effect of an ERP on costs of lung resection.**

Methods. **Adult patients undergoing elective lung resection from August 2011 to August 2013 at a single university-affiliated institution were prospectively recruited. Pneumonectomies and extended resections were excluded. Beginning in September 2012, patients were enrolled in a multimodal ERP. Outcomes were recorded until 90 days after discharge. Total costs from institutional, health care system, and societal perspectives are reported in 2016 Canadian dollars, with uncertainty expressed as 95% confidence intervals derived using bootstrapped estimates (10,000 repetitions).**

Results. **The study included 133 patients (conventional care: n = 58; ERP: n = 75). Patient and operative characteristics were similar between the groups. The ERP group had shorter median (interquartile range) length of stay (4 [3 to 6] days vs 6 [4 to 9] days, $p < 0.01$), decreased total complications (32% vs 52%, $p = 0.02$), and decreased pulmonary complications (16% vs 34%, $p = 0.01$), with no difference in readmissions. After discharge, there was a trend towards less caregiver burden for the ERP group (53 ± 90 hours vs 101 ± 252 hours, $p = 0.17$). Overall societal costs were lower in the ERP group (mean difference per patient: –$4,396 Canadian; 95% confidence interval –$8,674 to $618 Canadian).**

Conclusions. **A multidisciplinary ERP is associated with improved clinical outcomes and societal cost savings compared with conventional perioperative management for elective lung resection.**

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The concept of "fast-track surgery" was introduced more than a decade ago [1] and has evolved into the application of enhanced recovery pathways (ERPs) to improve surgical care. ERPs are evidence- and consensus-based protocols combining multiple interventions into a coordinated, standardized perioperative care pathway, with the goal to reduce the physiologic stress of the operation and help patients return to normal function [2]. Although initially reported for colorectal operations, multiple subsequent studies support the benefits of ERPs for other surgical procedures, including reduced complications, faster return of bowel function, shorter hospital stay, and lower medical costs, even when considering implementation and maintenance costs [3–5].

We and others have demonstrated the utility of ERPs for lung resection [6–10]. However, although a recent systematic review reported that ERPs might reduce length of stay and hospitalization costs for patients undergoing lung resection, the quality of the included studies was low [11]. Moreover, costs were reported from the hospital perspective [9, 12], which is highly influenced by the length of the primary hospitalization; however, no studies investigated the postdischarge socioeconomic effect of ERPs for lung resection, including subsequent health care system utilization and caregiver burden. The economic influence of ERPs is particularly important for lung resections because the number of pulmonary lobectomies performed in the United States is increasing

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[13], with an estimated cost of more than $1.9 billion annually [14]. Given that adoption of ERPs is also associated with implementation and maintenance costs [4, 5], a rigorous economic evaluation of these programs becomes essential to fully comprehend the financial impact before broader adoption. The aim of this study was to evaluate the effect of an ERP for lung resections on hospital, health care system, and societal costs.

Material and Methods

Study Design, Setting, and Participants

After obtaining approval from the Institutional Review Board, a prospective before/after cohort study was undertaken. We studied adults (aged >18 years) who underwent elective lung resections between August 2011 and August 2013 at the McGill University Health Centre (MUHC), a regional thoracic surgery referral center. Patients planned for elective anatomic or nonanatomic lung resection for lung cancer or benign lung disease by open or video-assisted thoracoscopic surgery (VATS) were included. Patients who had nonelective procedures, pneumonectomies, or extended resections (including chest wall or carina) were excluded. Patients were approached for enrollment in the study if they underwent preoperative assessment at MUHC within 2 weeks of the scheduled operation.

Beginning in September 2012, the management of patients undergoing elective lung resection followed a standardized ERP. Before this date, patients were managed based on surgeon preference ("conventional care" [CC]). Patient enrollment and data collection began in August 2011 and continued until August 2013, with

Table 1. Contrast Between Conventional Care and Enhanced Recovery Pathway Regarding Perioperative Patient Management[a]

Elements of Perioperative Management	CC	ERP
Preoperative		
Patient education	Non-standardized education given in surgeon's office	Standardized preoperative education protocol Information booklet with daily goals
Intraoperative		
Analgesia	Thoracic epidural inserted	Same
Extubation	Based on anesthesiologist preference	Preferred extubation in the operating room or in the postanesthesia care unit
Postoperative		
Analgesia	Thoracic epidural stop test performed on the day the last chest tube is removed	Same
Urinary drain	Nonstandardized management based on surgeon preference	POD 1: drain removed if adequate urine output If no urine output after 8 hours of removal, a bladder scan is performed and a urinary retention protocol is followed
Chest tube	POD 0: maintained at -20 cmH_2O suction Weaning based on surgeon preference	POD 0: maintained at -20 cmH_2O suction POD 1: remove suction POD 2: remove chest tube #1 if <300 mL/24 h, nonchylous and no air leak POD 3: remove chest tube #2 if <300 mL/24 h, nonchylous and no air leak
Nutrition	No nasogastric tube Diet advanced progressively based on surgeon preference	Same POD 0: clear fluid diet POD 1: diet as tolerated
Chest x-ray	After either chest tube suction removal or chest tube removal Clamp test based on surgeon preference	After either chest tube suction removal or chest tube removal No clamp test
Mobilization	Physical activity encouraged by health care provider	POD 0: up in chair with assistance as tolerated POD 1: up in chair 3 times per day for all meals + 30-60 minutes each time, ambulate in hallway 2 times per day with assistance POD 2: out of bed for all meals and ≥8 hours during the day, walking in hallway 17.5-35 meters 3 times per day with assistance POD 3: increase ambulation to 75 meters 3-5 times per day
Chest rehabilitation	Spirometry 10 times every hour while awake Chest physiotherapy every 4 hours	Same Same
Target discharge	None	POD 3 if 1 chest tube POD 4 if 2 chest tubes

[a] Adapted from [10] with permission from Elsevier.

CC = conventional care; ERP = enhanced recovery pathway; POD = postoperative day.