A Defined Esophagectomy Perioperative Clinical Care Process Can Improve Outcomes and Costs

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Esophagectomy (EG) is a high-risk therapy for esophageal cancer and end-stage benign disease. This study compares the results of EG before and after implementation of a perioperative clinical care process including a health provider education program (EP) and institutional uncomplicated postoperative clinical pathway (POP) for purpose quality improvement. This is a single institution retrospective cohort study. The EP was provided to critical care and telemetry unit nurses and the POP was imbedded in the electronic health record. Patients undergoing elective EG with reconstruction with the stomach for benign disease or cancer were included from 2005 to 2011. Cohorts were pre- and postimplementation (PreI and PostI) of an EP and 8-day POP (August 2008). Patient, tumor and peri/postoperative-specific variables were compared between cohorts, as well as resource utilization and hospital costs. We identified 33 PreI and 41 PostI patients. Both cohorts had similar patient demographics, preoperative comorbidities, majority cancer diagnosis, and for cancer patients, majority adenocarcinoma and IIB/III pathologic stage. Both groups had one death and similar rate of discharge to home. The PostI cohort demonstrated reduced 30-day readmission rate (2.4% *vs* 24.2%); $P < 0.05$. In regard to clinical outcomes, the PostI group exhibited reduced deep venous thrombosis/pulmonary emboli (2.4% *vs* 18.2%); $P < 0.05$. The PostI group demonstrated significantly reduced radiographic test utilization and costs, as well as total overall 30-day readmission costs. A defined perioperative clinical process involving educating the patient care team and implementing a widely disseminated POP can reduce complications, 30-day readmission rates, and hospital costs after EG.

Esophagectomy (EG) with reconstruction using the stomach is the gold standard therapy for esophageal cancer and end-stage benign esophageal disease. However, esophagectomy is a high-risk and complicated procedure that can be associated with elevated morbidity and mortality, prolonged length of stay, and hospital readmissions. In United States hospitals, esophagectomy carries mortality as high as 9 per cent with a 50 per cent complication rate and anastomotic leak accounting for many complications.[1] Data suggest that esophagectomy outcomes are superior at high-volume institutions and academic medical centers.[2, 3] More recent data demonstrate that those high-performing centers have similar complication rates as low-performing centers, but are better at rescuing their patients from complications, and therefore have a lower mortality than "failure to rescue" institutions.[4]

Defined clinical processes, which may include postoperative pathways, are a way to familiarize all patient care providers with the specific needs and nuances of high-risk procedures, resulting in fewer complications, and the identification of early complications, before said complications escalate.[5] In addition, postoperative pathways may reduce health-care resource utilization and costs of care.[6, 7] This study compares the results of elective esophagectomy before and after a period of transition where a defined perioperative esophagectomy clinical care process, where a regimented uncomplicated postoperative clinical pathway (POP) was implemented, and when intensive care unit (ICU) and ward nursing staff and other allied health professionals underwent a series of in-service lectures or education program (EP) on the indications for, technique and postoperative care nuances of esophagectomy. We hypothesized that the POP and EP improved patient outcomes, and reduced the cost of care for esophagectomy.

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Materials and Methods

The Institutional Review Board of the University of California, Davis Medical Center, approved this project. This is a single institution retrospective cohort review. As this is a retrospective cohort analysis, prospective patient consent was not obtained. During data collection, contact was not made with the patients, and all patient data is deidentified. We reviewed patients undergoing elective EG with reconstruction using the stomach for benign disease or cancer from 2005 to 2011. Cohorts were pre- and postimplementation (PreI and PostI) of an EP and seven day POP (August 2008).

Outpatient Preoperative Patient Education

During their outpatient preoperative visit, all patients' received education material on esophagectomy including a detailed description of the procedure, risks and benefits, recovery after esophagectomy, and diet after esophagectomy. In addition, all patients were given an incentive spirometer and instruction on how to use the incentive spirometer, and a schedule for usage. Moreover, all patients were asked to walk daily.

Surgical Procedure

Three types of esophagectomies were performed during this study. All patients were reconstructed using the stomach (conduit) pulled up and fashioned to the remaining esophagus (anastomosis). Transhiatal esophagectomy involves an incision in the upper abdomen and the left neck, with the stomach brought up behind the heart and reconnected (anastomosed) to the residual esophagus in the neck. An Ivor Lewis esophagectomy involves an incision in the upper abdomen and an incision in the right chest well (posterolateral thoracotomy), and the pulled up stomach conduit is anastomosed to the residual esophagus in the upper thoracic cavity. The third type of esophagectomy was a 3-hole or McKeown esophagectomy, which involves three incisions (three holes), a right posterolateral incision, upper abdomen and left neck, and the stomach conduit is pulled up and anastomosed to the residual esophagus in the neck in a similar fashion as the Transhiatal approach. The type of esophagectomy was determined by surgeon preference and the anatomic needs of the patient.

In all patients a feeding jejunostomy tube was surgically placed in the small bowel and either placed before the operation or at the time of the operation. This allowed for administration of enteric feedings or medications in the gastrointestinal track downstream from the foregut operation.

Pathway and EP

The POP was modeled after the University of Michigan experience that has proven to achieve long-term and durable results, but modified to fit our own institutional nuances.[8] The pathway provided daily guidelines for nine patient-care categories: consults, labs, radiographic tests, activity, treatments, diet, discharge planning, patient and family teaching, and medications. Key reminders in the POP include but are not limited to chemical and mechanical deep venous thrombosis (DVT) prophylaxis, magnesium, and perioperative beta-blockade administration to prevent postoperative arrhythmia, ambulation at least four times per day to prevent DVT/pulmonary emboli (PE) and pulmonary complications and promote bowel motility and prevent gastrointestinal complications, daily formal Cardiothoracic Surgery Protocol for respiratory therapy, and incentive spirometry use with the nursing staff every hour while awake to prevent pulmonary complications. A screening thin barium esophagram (barium swallow) was performed on postoperative day (POD) 7. For patients with intrathoracic esophagogastric (esophagus to stomach conduit) anastomosis (TEGA), oral intake was begun after POD 7 if the barium swallow demonstrated no leak from the anastomosis and no delayed emptying of the stomach conduit. For patients with cervical esophagogastric anastomosis (CEGA), oral intake was begun in step-wise fashion beginning on POD 3 or 4, culminating in a ground solid diet if the screening esophagram is negative. Chest and/or abdominal CT scans were not part of the routine assessment of the patient as defined by the POP. Nurses were given didactics on postoperative management of patients undergoing EG, with the following learning objectives: 1) To understand the surgical approach to esophageal disease, 2) to understand the importance of thoracic surgical postoperative clinical processes, 3) how to expeditiously identify anastomotic leaks, especially for CEGA, and 4) to understand the challenges of the healthcare system including such quality metrics as hospital readmissions and hospital revisits. Nursing didactics were held early in the morning at the change of shift to enable both "day" and "night" teams to be present.

To ensure maximal dissemination of the POP, the pathway was converted into a portable document format (PDF) and made accessible to all care providers via the health system electronic health record (EHR). The POP was purposely not incorporated into the functionality of premade order sets but made accessible just as a downloadable and printable PDF. We anticipated that it would be easier and faster to incorporate changes in the POP if it was a downloadable and printable PDF accessible through the EHR, as opposed to an integrated complex order set that would require maintenance by the EHR information technology team, and as a result, long turnaround time for changes.

The POP was provided to all residents and other trainees who rotated onto the general thoracic surgery service, new physician assistant hires, and other care staff who would have the opportunity to care for esophagectomy patients. On each page of the pathway is a statement: "Please note: This is a clinical guide. Deviation from the POP may occur at the Point-of-Care as clinically required." This statement is intended to prevent inappropriate adherence to the pathway that may be detrimental to the patient given a specific clinical situation. It is reported that many anastomotic leaks occur on POD 3 or later.[9] Beginning on the POD 3 page and each subsequent page of the pathway, a detailed description on how to expeditiously identify an anastomotic leak is listed.

Members of the Section of General Thoracic Surgery would meet annually to review the pathway, and make changes, if necessary, based on feedback from various stakeholders. This included general thoracic surgery faculty, Nurse Coordinator/Patient Navigator, physician assistants, and the head of the Department of Respiratory Care. Some elements that changed over time with the pathway included liberalization of the minimal chest tube drainage output for chest tube removal, based on new published data,[10] and transitioning from three times a day dosing of DVT/PE prophylactic subcutaneous low molecular weight heparin, to once a day dosing of subcutaneous Dalteparin (Eisai Co, Woodcliff Lake, NJ) for equivalent efficacy but improved patient comfort with just the once a day shot.[11]

In this study, patient-, tumor-, and peri/postoperative-specific variables were compared between cohorts.

Micro-cost Analysis

We analyzed costs by reviewing the standard charges for hospital board (ICU, telemetry surgical ward, and nontelemetry surgical ward) and radiographic tests (barium esophagram, chest CT scan with contrast and abdominal CT scan with contrast), and multiplying by the number of the above services rendered.

Patient and Hospital Demographics and Perioperative Outcomes

Patient demographics studied included age, sex, race, body mass index (BMI), and preoperative risk factors. Preoperative risk factors were diabetes mellitus (DM), cardiovascular (including hypertension, coronary artery disease, and congestive heart failure), neurologic (including history of stroke), renal (including chronic renal insufficiency), pulmonary (including chronic obstructive pulmonary disease), and history of smoking. Tumor-specific variables included histology, location of tumor (upper, mid, lower esophagus, and cardia of the stomach, which is beneath the junction of the stomach and esophagus), pathologic stage, and occurrence of neoadjuvant (before surgery) chemotherapy and/or radiotherapy. Perioperative outcomes measured included hospital length of stay (LOS) in days, occurrence of prolonged length of stay (PLOS) as defined by hospital stay >14 days, discharge disposition [routine to home, institutional care facility (ICF) or death at the time of discharge], and postoperative morbidity. PLOS was defined based on previous reported Society of Thoracic Surgery General Thoracic Surgery Database LOS measures.[12] Postoperative morbidity included cardiac complications (cardiac arrhythmia requiring medical intervention, myocardial infarction, or other), pulmonary complications (postoperative pneumonia, atelectasis requiring bronchoscopy, and other), nervous system complications (stroke, delirium requiring intervention, and other), renal complications (acute renal injury, and other), gastrointestinal complications (postoperative ileus, small bowel obstruction, and other), DVT/PE complications, surgical wound complications, urologic complications (urinary tract infection, urinary retention requiring discharge from the hospital with a urinary catheter, and other), anastomotic leak, and other (not otherwise categorized as above).

Statistical Analysis

Differences in the distribution of patient disposition/outcome [routine (to home), discharged to ICF or died], patient demographics (including age, sex, and race) and pre- and postoperative comorbidities were evaluated using the *t* test for continuous variables and Pearson's χ^2 and Fischer's exact testing for proportions. Binary logistic regression models were used to evaluate the likelihood (odds) of same-stay reoperation, 30-day readmission, and selected postoperative complications. All analyses were performed using PAWS Statistics 18.0 (SPSS, Armonk, NY) and Microsoft Excel Version 14.1.0 (Redmond, WA). All *P* values reported are for two-sided tests. Statistical significance was defined as $P \leq 0.05$.

Results

Patient Demographics

We identified 33 PreI and 41 PostI patients. Both cohorts had similar patient demographics in regards to age, majority male sex, BMI, preoperative comorbidities, and majority cancer diagnosis and for cancer patients, majority adenocarcinoma histology and IIB/III pathologic stage (Table 1). The PostI cohort had more patients with

TABLE 1. *Demographics for Patients Undergoing Esophagectomy*

	Pathway Cohort		
	Pre-I	Post-I	
Characteristic	% (n = 33)	% (n = 41)	*P* Value
Age	Mean 61.03 ± 10.58	Mean 65.17 ± 10.45	0.10
BMI	Mean 28.04 ± 5.54	Mean 29.05 ± 6.37	0.50
	%	%	
Sex			
Male	87.87 (29)	80.48 (33)	0.39
Female	12.13 (4)	19.52 (8)	
Race			
White	70.97 (22)	80.49 (33)	0.64
Black	8.74 (2)	4.89 (2)	
Other	22.59 (7)	14.63 (6)	
Smoking history	81.81% (27)	68.29% (28)	0.19
Preoperative risk factors			
Cardiovascular	60.61 (20)	68.30 (28)	0.49
DM	9.09 (3)	29.27 (12)	0.03
CKD	0.0 (0)	2.44 (1)	0.37
Neurological	3.03 (1)	4.88 (2)	0.69
Pulmonary	9.09 (3)	4.88 (2)	0.47
Cancer diagnosis			
Histology	93.94 (31)	92.68 (38)	0.83
Barrett's	6.45 (2)	0 (0)	0.11
Adenocarcinoma	77.42 (24)	81.58 (31)	0.67
Squamous cell	16.13 (5)	18.42 (7)	0.80
Tumor site			
Upper third	0.0 (0)	2.63 (1)	0.36
Middle third	9.68 (3)	10.53 (4)	0.91
Lower third	83.87 (26)	81.58 (31)	0.80
Cardia	3.23 (1)	5.26 (2)	0.68
Pathologic stage			
0	16.13 (5)	13.16 (5)	0.73
I	16.13 (5)	26.32 (10)	0.31
IIA	19.35 (6)	7.89 (3)	0.16
IIB	12.90 (4)	10.53 (4)	0.76
III	29.03 (9)	39.47 (15)	0.37
Preoperative radiation	30.30 (9)	42.11 (16)	0.26
Preoperative chemotherapy	32.26 (10)	52.63 (20)	0.09

CKD = Chronic kidney disease.

DM (29.3% *vs* 9.1% in the PreI group; $P = 0.03$). Both groups had one death (3.0% in the PreI group *vs* 2.4% in PostI, P = NS) and similar rate of discharge to home (87.9% *vs* 90.2%, P = NS).

Perioperative Characteristics and Outcomes

For the PreI cohort (data not shown) 15 EG were transhiatal (45.5%), 5 were Ivor Lewis (15.2%), and 13 were 3-hole McKeown (39.4%). In the PostI cohort 28 EG were transhiatal (68.3%), 8 were Ivor Lewis (19.5%), and 5 were McKeown (12.2%). The majority of PreI patients EG were performed in a multisurgeon team approach (n = 20, 60.6%; data not shown), with general surgeons performing the abdominal mobilization, and general thoracic surgeons performing the chest and/or neck dissections, and CEGA or TEGA. Only one EG in the PostI cohort was performed in a multisurgeon manner (2.4%, $P < 0.001$ *vs* PreI cohort; data not shown), the rest were performed by individual general thoracic surgeons.

In regard to perioperative outcomes (Table 2), the PostI cohort demonstrated reduced median LOS (9 days *vs* 15 days; $P = 0.009$) and incidence of PLOS (17.1% [n = 7] *vs* 55.5% [n = 18] $P = 0.001$) same-stay reoperations (9.8% [n = 4] *vs* 30.3% [n = 10] for PreI; $P = 0.03$), and 30-day readmission rate (2.4% [n = 1] *vs* 24.2% [n = 8]; $P = 0.004$); all $P < 0.05$/

In regard to clinical outcomes, the PostI group exhibited reduced pulmonary complications (19.5% [n = 8] *vs* 51.5% [n = 17]; $P = 0.004$) and DVT/PE (2.4% [n = 1] *vs* 18.2% [n = 6]; $P = 0.02$). There were no differences in the other measured postoperative morbidities including anastomotic leak.

A multisurgeon team (general surgery + general thoracic surgery) performed a majority of the PreI surgeries. Therefore, to determine which outcomes may be potentially confounded by the characteristic of multisurgeon

TABLE 2. *Perioperative/Postoperative Events*

Variable		Pre-I % (n = 33) Count	Pre-I % (n = 33) %	Post-I % (n = 41) Count	Post-I % (n = 41) %	P Value
Disposition	Home	29	87.88	37	90.24	0.95
	ICF	3	9.09	3	7.32	
	Died	1	3.03	1	2.44	
LOS		Median 15 days		Median 9 days		0.009
PLOS*		18	54.54	7	17.07	0.001
30-Day Readmission		8	24.24	1	2.44	0.004
Same-stay Reoperation		10	30.30	4	9.76	0.03
Postoperative morbidity						
Anastomotic leak		5	15.15	4	9.76	0.48
Pulmonary complications		17	51.52	8	19.51	0.004
Cardiovascular complications		8	24.24	12	29.27	0.63
DVT/PE		6	18.18	1	2.44	0.02
Neurovascular complications		0	0.0	0	0.0	N/A
Gastrointestinal complications		5	15.15	6	14.63	0.95
Urologic complications		3	10.00	3	7.32	0.78
Other complications		3	10.00	4	9.76	0.66

Perioperative/postoperative events comparing multisurgeon surgery team to single surgeon within the PreI Cohort

Variable		Multi-surgeon (n = 20) Count	Multi-surgeon (n = 20) %	Single Surgeon (n = 13) Count	Single Surgeon (n = 13) %	P Value
Disposition	Home	17	85.00	12	92.31	0.74
	ICF	2	10.00	1	7.69	
	Died	1	5.00	0	0.0	
LOS		Median 23 days		Median 10 days		0.04
PLOS*		14	70.00	4	30.77	0.04
30-day readmission		6	30.00	2	15.38	0.34
Same-stay reoperation		7	35.00	3	23.08	0.70
Postoperative morbidity						
Pulmonary complications		13	65.00	4	30.77	0.08
DVT/PE		5	25.00	1	7.70	0.36

* PLOS if >14 days.

surgical approach or single surgeon approach, the variables in Table 2 were reanalyzed by performing a subanalysis of the PreI cohort, comparing the 13 EG performed by single surgeon to 20 cases performed by a multisurgeon team (Table 2). Compared with multisurgeon surgical cases, single surgeon cases in the PreI cohort exhibited improved median LOS and incidence of PLOS (both $P = 0.04$) but no differences in the other Table 2 significant variables.

In addition, there is heterogeneity in the type of esophagectomy performed; transhiatal or transthoracic (Ivor Lewis or McKeown esophagectomy). To determine which outcomes may be potentially confounded by the esophagectomy technique, the variables in Table 2 were also reanalyzed by comparing outcomes for the 43 transhiatal esophagectomy patients to the 31 transthoracic esophagectomy patients. Patients who underwent transhiatal esophagectomy demonstrated lower median LOS and incidence of PLOS ($P = 0.02$ and $P = 0.01$, respectively) compared with patients undergoing transthoracic esophagectomy (Table 3). In regard to postoperative morbidity, transhiatal esophagectomy patients exhibited lower incidence of pulmonary complications ($P = 0.01$) and GI complications ($P = 0.03$), and no difference in incidence of DVT/PE ($P = 0.10$), and the other significant variables illustrated in Table 2. Of note, there was also no difference in the incidence of anastomotic leak between the two techniques ($P = 0.38$).

Odds of 30-day Readmission, Same-stay Reoperation, and Pulmonary Complications and DVT/PE

Including in the model cohort type, age, preoperative chemotherapy history, smoking history, DM, pulmonary and cardiovascular risk factors, BMI, sex, and incidence of anastomotic leak, we performed a multivariate analysis to determine independent predictors of 30-day readmission, same-stay reoperation, pulmonary complications and DVT/PE (Table 4). PreI status was an independent predictor of 30-day readmission [odds ratio (OR) 39.2, confidence interval (CI) 2.2–702.9; $P = 0.01$], same-stay reoperation (OR 10.7, CI 1.5–77.1; $P = 0.02$), and pulmonary complications (OR 6.3; CI

Table 3. *Perioperative/Postoperative Events Comparing Transhiatal to Transthoracic Esophagectomy*

Variable		Transhiatal (n = 43) Count	%	Transthoracic (n = 31) Count	%	P Value
Disposition	Home	39	90.70	27	87.10	0.23
	ICF	4	9.30	2	6.45	
	Died	0	0.0	2	6.45	
LOS		Median 9 days		Median 15 days		0.02
PLOS*		9	20.93	16	51.61	0.01
30-day readmission		4	9.30	5	16.13	0.38
Same-stay reoperation		6	13.95	8	25.81	0.20
Post-operative morbidity						
Pulmonary complications		9	20.93	16	51.61	0.01
DVT/PE		2	4.65	5	16.13	0.10
GI complications		3	7.00	8	25.81	0.03
Anastomotic leak		4	9.30	5	16.13	0.38

* PLOS if > 14 days; GI, gastrointestinal.

Table 4. *Predictors of 30-day Readmission, Same-Stay Reoperation and Pulmonary Complications*

Variable	OR	95% CI	P value
30-day Readmission			
Pre-I	39.17	2.18–702.86	0.01
Same-stay Reoperation			
Pre-I	10.70	1.48–77.14	0.02
No anastomotic leak	0.03	0.002–0.46	0.01
Pulmonary Complications			
Pre-I	6.27	1.66–23.67	0.007

1.7–23.7; $P = 0.007$). After multivariate analysis, PreI was not an independent risk factor for DVT/PE. Freedom from anastomotic leak reduced the likelihood of a same-stay reoperation (OR 0.03, CI 0.002–0.5; $P = 0.01$)

Micro-cost Analysis

Post-I cohort demonstrated (Table 5) a trend toward reduced Average Initial Hospital Board Costs per Patient (ICU + telemetry ward + nontelemetry ward costs for primary admission) compared with the PreI cohort, though not significant ($189, 217.17 for PostI *vs* 298,601.52 for PreI, $P = 0.08$). The PostI cohort exhibited reduced Average Initial Radiographic (esophagram + chest CT + abdominal CT during primary hospital admission) Costs per Patient ($2,607.12 for PostI *vs* $8,383.58 for PreI, $P < 0.001$), resulting in a trend toward reduction in Average Total Initial Costs per Patient (total board costs + radiographic costs for primary hospital admission; $191,824.29 for PostI *vs* $306,985.09 for PreI, $P = 0.07$). In addition, the PostI cohort demonstrated reduced Accumulative 30-day Readmission (ICU and telemetry/nontelemetry ward board + total radiographic costs during readmission) Costs ($42,670.00 for PostI *vs* $787,779.00 for PreI, $P = 0.01$).

Discussion

Clinical pathways are a method of organizing, making efficient, and standardizing clinical care processes. The organization provided by care pathways promotes transparency in clinical performance and care strategy. The Institute of Medicine called for the organization of care processes to foster transparency and patient centeredness.[13, 14] “Failure to rescue” is a concept that has gained awareness in the surgical community in the past five years.[4] This concept suggests that successful centers that perform complex surgery, such as esophagectomy, may have similar complication rates as low-performing centers, but they are able to rescue their patients better from those complications. Institutions that excel in rescuing their surgical patients from common complications may do so by optimizing clinical pathways.[5]

In an observational field study, Symons et al. followed 50 patients undergoing major elective general surgery for their entire postoperative care, and found 256 clinical process failures, of which 85 per cent were preventable and 51 per cent directly led to patient harm.[15] The authors found that communication failures and delays led to 54 per cent of the process failures. In a similar designed study, Nagpal et al. followed 20 patients undergoing major gastrointestinal surgical procedures and found that 75 per cent of patients had adverse events or clinical incidents that were a result of information transfer and communication failures.[16] Pathway structured clinical processes that concentrate on 1) patient-focused organization, 2) coordination of the care process, 3) communication with patients and family, 4) collaboration with primary care, and 5) follow-up of the care process may minimize communication breakdowns and improve outcomes.[17]

In our study, a structured health-care provider EP, and a defined POP improved outcomes as measured by

TABLE 5. *Microcost Charge Analysis*

Characteristic	Pathway Cohort Pre-I $	Post-I $	*P* value
*Average initial board costs per patient	298,601.52	189,217.17	0.08
†Average initial radiographic costs per patient	8,383.58	2,607.12	<0.001
‡Average total initial costs per patient	306,985.09	191,824.29	0.07
§Accumalative 30-day readmission costs	787,779.00	42,670.00	0.01

* ICU + ward + telemetry floor costs for primary admission.
† esophagram + chest CT + abdominal CT costs for primary admission.
‡ board costs + Radiographic costs for primary admission.
§ board costs + radiographic costs for total cohort 30-day readmission.

30-day readmission rates, same-stay reoperations, pulmonary complications, and improved hospital costs, including radiographic costs and the costs of readmission. The didactics program is designed to educate the nursing teams on the basics of esophagectomy, including indications, how the gastric conduit is positioned in the body, and where TEGA and CEGA are located. In addition, the nursing team was instructed on the risk factors, signs and symptoms and identification of anastomotic leaks.[9] The early identification of leaks by the nursing, resident, and allied health support staff allowed for expeditious treatment and preventing the not-uncommon complication of anastomotic leak from escalating into a bigger problem, leading to "failure-to-rescue."

The pathway is strategically disseminated and made accessible to all stakeholders providing care for esophagectomy patients. Our results, especially in regard to costs, mirror the limited previously reported analyses on the efficacy of postoperative pathways as well as a lean efficiency approach to peri- and postoperative care of the esophagectomy patient.[18–20] Reduction in radiographic costs may stem from the standardized approach to the identification of anastomotic leaks.[9] Screening barium swallow studies were done on POD 7, for all types of esophagectomies, unless the patient developed a clinical leak before POD 7. Suspected clinical leaks that were not obvious were evaluated by barium swallow regardless of POD. The radiographic means of evaluating the anastomosis was standardized by using a simple, low-cost technique. Improvements in pulmonary complications may be attributable to defined communication with the respiratory therapists and pulmonary toilet expectations built into the pathway, in addition to early mobilization and a defined out-of-bed and walking schedule. Minimization of 30-day readmission potentially is a byproduct of the structured communication between the health-care provider teams and the patient and patient families, resulting in less confusion upon discharge. Reduced same-stay reoperations may be a result of the quick identification of complications, and rescuing patients from said complications in an expeditious manner. There was a significant reduction in DVT complications. Although the formal DVT chemical and mechanical (lower extremity sequential compression devices) prophylaxis regimen was similar in both cohorts, there was daily emphasis on implementing administration of chemical prophylaxis and sequential compression devices in the POP. In addition, there was emphasis on early ambulation and standardization on the number of times the patient walked (four times per day), and sat in a chair (three times per day), all of which reduce the incidence of DVT.

The cost evaluation in our study is novel, specifically in regard to radiologic utilization. Additional prospective studies are planned that will evaluate cost savings in regards to our pathway not only from reduction in health-care utilization, such as unnecessary radiologic exams and laboratory tests, but also a reduction in health-care utilization as a result of diminished complications.

Limitations of this study are its retrospective design and the small overall patient numbers. The smaller patient numbers prevents a propensity-matched analysis. In addition, there is heterogeneity in both the surgical technique and the make-up of the surgeons performing EG. The majority of the PostI cohorts EG were transhiatal esophagectomy with CEGA, and the PreI cohort included transhiatal and transthoracic esophagectomy with CEGA and TEGA. Hulscher et al. performed a prospective trial randomizing 220 patients to either transhiatal esophagectomy or 3-hole esophagectomy with extended en bloc lymphadenectomy for cancer.[21] Patients undergoing the transthoracic approach exhibited higher perioperative morbidity, but no difference in survival. In that study, there was a 16 per cent attrition rate and no patients received preoperative chemotherapy or radiotherapy. However, more recent clinical reports demonstrate clinical equivalency of esophagectomy with and without thoracotomy, especially not involving extended en bloc lymphadenectomy, in regard to both perioperative and long-term outcomes.[1, 22, 23] Most recently Gopaldas et al. analyzed from the Nationwide Inpatient Sample 40,589 patients who underwent esophagectomy, and found operative technique (transthoracic or transhiatal) did not independently affect risk-adjusted outcomes, specifically mortality, morbidity, and failure to rescue.[23] The more recent reports suggest the likelihood of the choice of surgical procedure biasing the perioperative results is low. However, our subanalysis did show that the patients undergoing transhiatal EG exhibit lower LOS, incidence of PLOS, and pulmonary complications compared with patients undergoing transthoracic EG, therefore potentially confounding the results of our PostI cohort, where the EP and POP resulted in improvement in the aforementioned outcomes.

Another potential confounder is that 60.6 per cent of PreI patients EG were performed in a multisurgeon manner with general surgeons performing the abdominal mobilization, and general thoracic surgeons performing the chest and/or neck dissections and CEGA or TEGA. In the PostI cohort, 97.6 per cent of the EG were performed by individual general thoracic surgeons. Dimick et al. observed improved outcomes in patients who had their esohagectomy performed by American Board of Thoracic Surgery certified surgeons compared with nonthoracic surgeons.[24] Our group has previously demonstrated that the majority of esophagectomies performed at academic medical centers (centers purported to have the best outcomes) are performed by general thoracic surgeons.[25] Although the PostI cohort exhibited reductions in LOS and incidence of PLOS, conclusions on the effect of EP and POP on those improved outcomes cannot be definitive as the subset analysis of the PreI cohort also showed that EG performed by individual surgeons had significantly reduced LOS and incidence of PLOS when compared with EG performed by a multisurgeon surgical team. These observations may demonstrate that even in the PreI cohort, an individual surgeon approach might foster uniformity in communication, reduced variability in plan and treatment strategy, resulting in reduced LOS.

Finally, an additional limitation is our use of 30-day mortality and not 90-day mortality. 90-day mortality has been proposed to be a more accurate assessment of esophagectomy quality and potential for mortality. Walters et al. demonstrated a doubling of mortality when comparing 90-days to 30-day follow-up for patients undergoing esophagectomy in an analysis of the surveillance, epidemiology, and end results-medicare registry.[26] We examined 30-day mortality for the following reasons: 1) at the time of our study, 30-day mortality was the standard of care follow-up. In addition, other quality datasets such as the Nationwide Inpatient Sample abstract only discharge mortality. 2) Many of our patients are form a rural geographic area, more than a 2-hour distance from our urban medical center. As a result, after the perioperative period (roughly 30 days), many patients chose to have their cancer surveillance and other follow-up care performed by their local community health-care providers for convenience.

Educating the patient care team and implementing a POP can reduce complications, same-stay reoperations, 30-day readmission rates, and hospital costs after EG. This study blueprints how an institution can evolve a successful EG program through a structured approach. The POP is being expanded to other complex thoracic surgical procedures, and is being used as a foundation for the development of a patient-centered protocol, where the patient and patient's family are active participants in the identification of each milestone within the pathway. Patient engagement in pathway implementation may prevent a "Hawthorne Effect" where the care team takes a clinical care pathway for granted, negatively affecting adherence. It is anticipated that the POP for various complex thoracic surgical procedures will be scalable to multiple institutions, specifically community and rural hospitals that are limited by small clinical volume, but do perform thoracic surgery.

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