



# Combined endo-laparoscopic surgery (CELS) for benign colon polyps: a single institution cost analysis

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## Abstract

**Background** Endoscopic removal of benign colon polyps is not always possible, even with advanced endoscopic techniques. Segmental colectomy has been the traditional therapy but is associated with an increased risk of complications and may be unnecessary since fewer than 20% of these polyps harbor malignancy. Combined endo-laparoscopic surgery (CELS) has emerged as an alternative method to address these polyps. While feasibility, safety, and improved short-term patient outcomes have been demonstrated, there has never been an evaluation of cost comparing these two approaches within a single institution.

**Methods** In this observational cohort study, we compared short-term outcomes and costs of 11 patients who underwent CELS for right colon polyps with 11 patients who underwent a laparoscopic right colectomy between April 2014 and November 2017. The cost analysis covered the perioperative period from operating room to hospital discharge.

**Results** A total of 11 patients underwent an attempted CELS procedure for right colon polyps with a success rate of 90% (10/11). The median length of stay (LOS) for CELS patients was 1 day. LOS for patients who underwent a laparoscopic right colectomy at TMC was 3.82 days. The median OR time for CELS was 166.73 ( $\pm 57.88$ ) min, compared to 204.73 ( $\pm 51.49$ ) min for a laparoscopic right colectomy. The calculated total cost for a CELS patient was \$5523.29, compared to \$12,626.33 for a laparoscopic right colectomy, for a cost-savings of \$7103.04 per patient.

**Conclusions** CELS procedures are associated with good short-term outcomes and are performed at a lower cost compared to traditional laparoscopic colectomy, with the most significant cost saver being shorter hospital LOS. This is the first study to directly compare the cost of CELS to traditional laparoscopic colectomy in the surgical management of benign colon polyps within a single institution.

**Keywords** Combined endo-laparoscopic surgery (CELS) · Colon polyp · Cost analysis

Endoscopic removal of benign colon polyps is not always possible, even with advanced endoscopic techniques including endoscopic mucosal resection and endoscopic submucosal dissection. Some polyps prove difficult to resect endoscopically due to size, location, scarring from previous biopsies, or difficult visualization due to anatomic constraints [1]. While segmental colectomy has been the traditional therapy for management of these polyps, fewer than

20% of these polyps harbor malignancy and a bowel resection is associated with an increased complication risk [2, 3].

In 1993, a laparoscopic-assisted full-thickness endoscopic polypectomy was introduced, and since then combined endo-laparoscopic surgery (CELS) has developed as an alternative method to address these complex, benign-appearing polyps that would traditionally be treated by colectomy [4]. With CELS, endoscopic removal of complex polyps is assisted by laparoscopic manipulation of the bowel wall to facilitate polyp removal, potentially avoiding a bowel resection and its associated risks.

Despite the wide adoption of minimally invasive approaches, patients undergoing traditional surgical treatment of these polyps must still undergo a major bowel resection and a relatively long post-operative stay for a polyp that is likely to be benign [3]. When a CELS polypectomy is

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successfully performed, many of the perioperative complications of a laparoscopic colectomy can be avoided and the post-operative period has been shown to be much shorter [2, 5]. While feasibility, safety, and improved short-term patient outcomes have been demonstrated using CELS, there has never been an evaluation of cost comparing CELS with a laparoscopic colectomy [6]. Our goal was to review the CELS experience at our institution and to evaluate the hospital costs of patients who underwent CELS for a right-sided polyp with patients who underwent a laparoscopic right colectomy.

## Methods

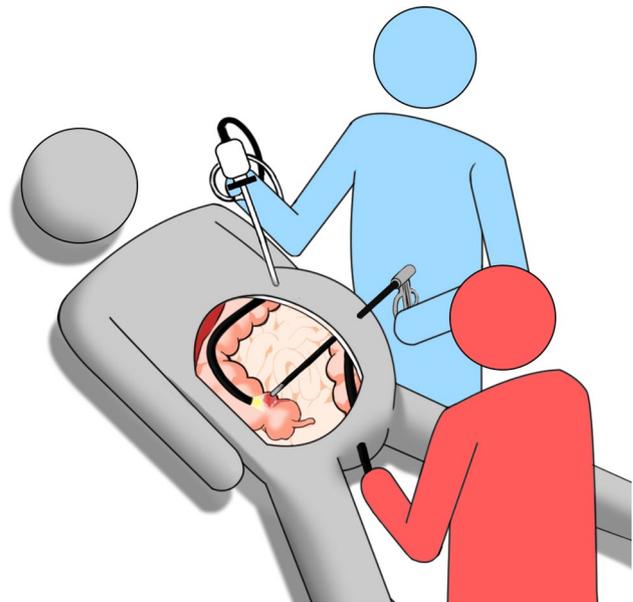
In this observational cohort study, we compared the short-term outcomes and costs of 11 patients who underwent CELS for right colon polyps and 11 patients who underwent a traditional laparoscopic right colectomy at a large tertiary care center (Tufts Medical Center, TMC) between April 2014 and November 2017. The cost analysis covered the perioperative period from operating room to hospital discharge. Microcosting estimates were obtained from the literature and applied to our specific operating room time and length of stay (LOS) data for our cohorts [7–9]. A modified societal perspective was used as the costing structure, with all cost estimates obtained for university hospital settings. The study was approved by the Tufts Medical Center Institutional Review Board.

## Inclusion/exclusion criteria

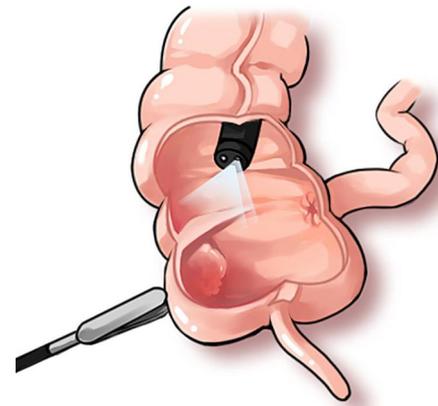
We examined all patients who underwent an elective CELS procedure for right colon polyps at a large tertiary care center between April 2014 and November 2017. These patients were compared to patients who underwent an elective laparoscopic right colectomy over the same time period.

## Surgical technique

Patients undergoing CELS receive a bowel preparation prior to surgery. Following general endotracheal anesthesia and placement of a Foley catheter and orogastric tube, patients are placed in modified lithotomy position. Pneumoperitoneum is established and one to two additional 5-mm trocars are placed. The peritoneal cavity is carefully examined and if the polyp was previously tattooed, the inked area is identified. Next, the endoscopist, standing between the legs of the patient, performs an intra-operative colonoscopy (Fig. 1) using carbon dioxide as the insufflating gas to minimize bowel distention [10]. The intraluminal location of the polyp is identified and is correlated with its location externally using laparoscopic instruments

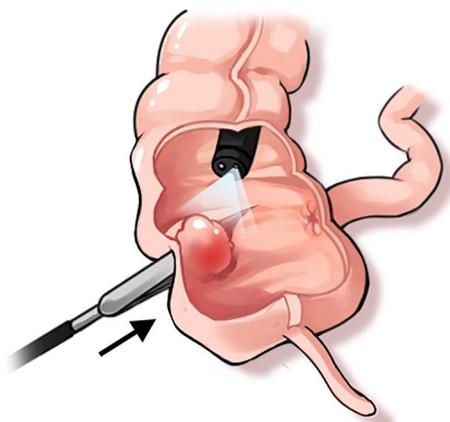


**Fig. 1** Operating room setup for CELS. The patient is positioned in modified lithotomy position. Laparoscopy is performed by the surgeon who stands on the side of the patient while the endoscopist performs an intra-operative CO<sub>2</sub> colonoscopy, positioned between the legs of the patient



**Fig. 2** Polyp identification by CELS. The intraluminal location of the polyp is identified and is correlated with its location externally using laparoscopic instruments

(Fig. 2). Depending on the location of the polyp, mobilization of the bowel may be required prior to CELS polypectomy so that the external surface of the colon wall can be manipulated easily and evaluated for potential serosal injury. The polyp is removed using standard endoscopic techniques, with external manipulation of the bowel wall as needed to facilitate polyp removal (Fig. 3). Careful assessment of the serosal surface is performed to evaluate for full thickness injury at the time of polypectomy, and a repair is performed if necessary.



**Fig. 3** Polyp management with CELS. External manipulation of the bowel wall with laparoscopic instruments can facilitate polyp removal

## Results

We identified 11 patients with endoscopically unresectable polyps who underwent an attempted CELS procedure from April 2014 to November 2017. Polyps were located in the cecum in five patients, in the ascending colon in four patients, and in the proximal transverse colon in two patients (Table 2). Of these 11 patients, 10 had successful polyp removal (90.9%) using the CELS technique. One patient had a fixed polyp that was not removable by CELS and required a laparoscopic right colectomy. Her pathology was consistent with a tubular adenoma.

The average LOS for CELS patients was 1 day with a range of 0 to 3 days (Table 1). Post-operative complications occurred in one patient, who developed a post-polypectomy bleed following resumption of anti-platelet therapy (Plavix). Of the ten patients who had a successful CELS procedure, nine of these polyps were ultimately benign and adenocarcinoma was present in one. This patient underwent a laparoscopic right colectomy 12 days

**Table 2** Colon polyp/cancer location

CELS patients	
Cecal	5
Ascending colon	4
Transverse colon	2
Laparoscopic right colectomy patients	
Cecal	6
Ascending colon	3
Transverse colon	2

later. The final pathology was consistent with a T1N0 cancer (no residual cancer was found in the resected specimen, 0/20 lymph nodes).

Patients who underwent a laparoscopic right colectomy had a known diagnosis of colon cancer, or had polyps that were not removable endoscopically and on evaluation, were not felt to be candidates for CELS. The colon lesions were located in the cecum in six patients, in the ascending colon in three patients, and in the transverse colon in two patients (Table 2). Average LOS for the patients undergoing a laparoscopic right colectomy was 3.82 days with a range of 2–5 days. Five patients had benign tumors and six patients had adenocarcinoma. One patient experienced lower GI bleeding on post-operative day 1 that required a blood transfusion and a return to the OR for endoscopic clip placement.

Two sample independent *t* tests were used to analyze differences between the two groups. There was no difference in age, BMI, or mean operating room time. The difference in the LOS was found to be statistically significant ( $p = 3.29 \times 10^{-7}$ ), with the CELS patients staying on average 2.82 days less (Table 1).

## Cost-analysis

The cost analyses were constructed based on mean hospital costs as these values are less variable than pricing and billing data within the healthcare system [6]. The hospital cost difference between these two procedures is broken down

**Table 1** Patient & procedure information

	CELS patients N=11	Right laparoscopic colectomy patients N=11	<i>p</i> -value
Mean age at surgery ( $\pm$ SD)	59.27 years ( $\pm$ 6.03)	61.09 years ( $\pm$ 11.51)	0.653
Female/male	5/6	7/4	
BMI ( $\pm$ SD)	28.27 kg/m <sup>2</sup> ( $\pm$ 6.05)	30.43 kg/m <sup>2</sup> ( $\pm$ 7.07)	0.459
Mean operative time ( $\pm$ SD)	166.73 min ( $\pm$ 57.88)	204.73 min ( $\pm$ 51.49)	0.129
Mean LOS ( $\pm$ SD)	1 day ( $\pm$ 0.85)	3.82 days ( $\pm$ 0.87)	$3.29 \times 10^{-7}$ *
Polyp size ( $\pm$ SD)	27.95 mm ( $\pm$ 9.16)	28.00 mm ( $\pm$ 14.95)	0.993

\*Statistically significant  
SD standard deviation

into ‘inpatient stay’ and ‘OR time.’ The following financial data were calculated based on mean inpatient costs among all hospitals within the United States and mean operating room cost data from the largest available cost matrix [7, 8].

The first component of analysis is inpatient cost. The national mean cost of inpatient stay in 2014 is \$2212/day [7]. Given a 2.82 day change in duration, there is a \$6327.84 savings with the CELS procedure (Table 3). The second component of assessed hospital cost is OR time. The calculated OR costs are based on direct costs, which include salaries/benefits, non-billable supply items, depreciation of equipment, utilities, leases, and insurance. The final cost value for procedures done in 2014 was determined to be \$20.40/min [8]. Given a decrease in OR time of 38 min, the CELS procedure decreases OR cost by \$775.20.

Therefore, due to the decrease in OR time of 38 min and a decrease in LOS of 2.82 days, the CELS procedure results in an average cost reduction of \$7103.04 per case.

## Discussion

For polyps that are unresectable through endoscopy, the CELS procedure is proving to be a reasonable alternative to a formal bowel resection in selected patients, and this cost-analysis demonstrates the first indications that it is also a more cost-effective procedure.

The primary indicator of decreased cost was a shortened LOS, due to the less invasive nature of the procedure. Several studies showed that once teams became familiar with the procedure by operating on more than 20 patients, the LOS would be dramatically reduced [2, 11, 12]. Furthermore, this cohort of patients demonstrated a decrease in OR time, that saved \$775.20 on average.

Although not demonstrated in the study, considering its small cohort size, other studies suggest that CELS has fewer post-operative complications when compared to a laparoscopic colectomy [6]. Though we limited our cost analysis to

operating room costs and the length of hospitalization, future studies aim to perform a more comprehensive longer term cost analysis. This would include the cost of post-operative complications (both short-term complications such as wound infections and UTIs and long term complications such as incisional hernias), as well as the need for endoscopic follow-up, which may possibly increase costs associated with the CELS approach. The cost of an additional physician (endoscopist) also was not part of this initial study. There is also the cost of a second operation if a CELS polypectomy is successfully performed, but pathology demonstrates cancer. With the number of such patients being much lower than those who have benign polyps, this financial and best-practice-related decision must be discussed between patient and surgeon in deciding the best course of treatment. Improving patient care with cost-efficient procedures that may prove non-inferior has benefits beyond costs saved if the clinical results also prove superior. In addition, the significantly decreased LOS frees up hospital resources to accommodate additional surgical patients.

An additional area for cost-efficiency but one that was not analyzed here is the debated need for frozen pathology during the procedure. A frozen section analysis increases intra-operative time by approximately 30 min and also increases the overall perioperative cost. Frozen sections will only identify a small number (around 2%) of unexpected malignancies and also may not be the most accurate method to identify malignancies [3, 5]. Some groups suggest using frozen section only for highly suspicious malignancies given the high false negative rate and additional cost [13, 14]. Frozen sections were performed in three of our first four CELS patients, and were later abandoned as standard practice.

There are several limitations to this study. The retrospective nature of this study and its small cohort size limits the generalizability of the analysis. Costs can also vary from hospital to hospital based on location and nation to nation based on healthcare system. Furthermore, we were not able to analyze the impact of insurance status, other socio-economic factors, or personal reasoning upon the decision to undergo CELS versus a laparoscopic right colectomy. Research into these additional patient characteristics could further elucidate the population for which this procedure is best. Future studies are needed to evaluate both short- and long-term costs using intention to treat analysis and a larger sample size.

## Conclusion

In the perioperative period, successful CELS procedures are performed at a lower cost compared to traditional laparoscopic colectomy, with the most significant cost saver being shorter hospital LOS with additional savings on decreased

**Table 3** Cost analysis

	CELS	Segmental colectomy
LOS in days	1	3.82
Cost/day	\$2212	\$2212
Total LOS cost	\$2212	\$8449.84
Total change per case (LOS)		\$6327.84
Minutes	166.73	204.73
Cost/min	\$20.40	\$20.40
Total OR cost	\$3401.29	\$4176.49
Total change per case (OR time)		\$775.20
Total cost	\$5523.29	\$12,626.33
Total savings per case		\$7103.04

OR times. This is the first study to directly compare the cost of successful CELS to traditional laparoscopic colectomy in the surgical management of benign colon polyps within a single institution.

### Compliance with ethical standards

**Disclosures** Anusha Jayaram, Nathan Barr, Robert Plummer, and Drs. Mengdi Yao, Lilian Chen, and James Yoo have no conflicts of interest or financial ties to disclose.

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