The cervicosternolaparotomy approach for the treatment of graft dysfunction after retrosternal esophageal reconstruction for caustic injuries

Thibault Voron, MD, Morgan Anyla, MD, Helene Corte, MD, Eric Roland, MD, Nicolas Munoz-Bongrand, MD, Emile Sarfati, MD, Pierre Cattan, MD, PhD, and Mircea Chirica, MD, PhD

ABSTRACT

Objective: The study purpose was to report the indications, technical aspects, and outcomes of cervicosternolaparotomy during revision surgery after esophageal reconstruction for caustic injuries.

Methods: Patients who underwent cervicosternolaparotomy during revision surgery for graft dysfunction between 1999 and 2015 were included. Cervicosternolaparotomy was performed to mobilize and pull up the primary conduit during surgery for strictures (rescue cervicosternolaparotomy) or to allow retrosternal access for management of other graft-related complications (exposure cervicosternolaparotomy). Statistical tests were performed to identify factors associated with primary conduit preservation during rescue cervicosternolaparotomy.

Results: Fifty-five patients were included (28 men; median age, 43 years). Median delay between primary reconstruction and cervicosternolaparotomy was 15 months. Exposure cervicosternolaparotomy was performed in 12 patients (22%) for redundancy ($n = 8$), spontaneous perforation ($n = 2$), and caustic re-ingestion ($n = 2$). Rescue cervicosternolaparotomy was performed in 43 patients (78%) to treat supra-anastomotic ($n = 11$), anastomotic ($n = 23$), and diffuse ($n = 9$) stenosis. During rescue cervicosternolaparotomy, the primary conduit was preserved in 32 patients; median length gain obtained by transplant release was 8 cm. Failure to preserve the primary conduit was associated with previous surgical repair attempts ($P = .003$) and lack of initial concomitant pharyngeal reconstruction ($P = .039$). Two patients died (4%), and 35 patients (64%) experienced operative complications. Operative outcomes were similar after rescue and exposure cervicosternolaparotomy. With a median follow-up of 4.4 years, the functional success rate was 85%.

Conclusions: Cervicosternolaparotomy during revision surgery for graft dysfunction is reliable, is associated with low morbidity and mortality, and has good results. (J Thorac Cardiovasc Surg 2016;152:1378-85)

CSLap: Interrupted lines mark thorax limits.

Central Message

Cervicosternolaparotomy during revision surgery for graft dysfunction after caustic injury is associated with acceptable morbidity and has good results.

Perspective

Revision surgery after esophageal reconstruction for caustic injuries is hindered by the retrosternal graft position, limiting treatment by the cervical or abdominal approach. Cervicosternolaparotomy offers an appropriate graft access enabling specific management of graft dysfunction and is associated with low mortality (4%) and high functional success (85%) rates.

See Editorial Commentary page 1386.

The retrosternal route is the gold standard for transplant ascension during esophageal reconstruction for caustic injuries.¹⁻⁵ In expert centers, mortality and morbidity of esophageal reconstruction are low and most patients regain the ability to

eat and drink without the need for supplementary tube feeds.^{1,2,4-7} However, late complications consisting mostly of strictures and redundancy occur in up to half of the patients during follow-up and may lead to loss of function.^{5,8-12} Revision surgery for graft dysfunction has been reported in 15% to 38% of patients and can be a difficult challenge.^{12,13} The esophageal substitute traverses 3

From the Department of General, Endocrine, and Digestive Surgery, Saint-Louis Hospital, AP-HP, Université Paris 7 Diderot, Paris, France.

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Address for reprints: Thibault Voron, MD, Centre Hospitalier Universitaire Saint-Louis, 1 avenue Claude Vellefaux, 75475 Paris Cedex 10, France (E-mail: thibault.voron@gmail.com).

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Abbreviation and Acronym

CSLap = cervicosternolaparotomy approach

compartments (abdomen, thorax, and neck), and its longer part is located behind the sternum. Revision surgery can be performed occasionally by a limited cervical or abdominal approach, but in most cases, access to the graft is hindered by the sternum.

Bridging of cervical gaps by free jejunal grafts¹⁴ or by fasciocutaneous and myocutaneous flaps¹⁵⁻¹⁷ has been reported for the treatment of long cervical strictures. Nevertheless, such procedures have failed to gain wide acceptance in current practice because of technical difficulties requiring experience in microsurgical techniques, high risks of graft necrosis, substantial mortality, and disappointing functional outcomes. In 1994, Wu and colleagues¹⁸ described successful mobilization of the colonic transplant by cervicotomy and sternotomy during revision surgery for graft strictures. In 2001, our group reported the successful use of the cervicosternolaparotomy approach (CSLap) to treat extended cervical stenoses after esophageal reconstruction for caustic injury.¹⁹ Transplant release by CSLap provided a median 6-cm length gain and allowed primary repair of the cervical anastomosis in 5 of 8 patients; 3 patients failed transplant preservation and underwent secondary esophagocoloplasty during the same operation.¹⁹ Indications for CSLap have been progressively expanded to treat other graft-related complications (redundancy, perforation), and the number of CSLap procedures performed in our center has increased steadily.

During the last 30 years, the Saint-Louis Hospital in Paris has progressively become the referral center for the treatment of caustic injuries of the upper gastrointestinal tract and esophageal reconstruction–related complications in patients residing in Paris and the suburbs (serving a population of 13 million).²⁰ We report our experience with 55 patients who underwent CSLap during revision surgery for graft dysfunction after esophageal reconstruction for caustic injuries.

PATIENTS AND METHODS

Patients

Between January 1999 and May 2015, patients aged more than 16 years who underwent CSLap during revision surgery for graft dysfunction after esophageal reconstruction for caustic injuries were the subjects of the study. The study was approved by the Saint-Louis Hospital Ethics Committee.

Indications for Cervicosternolaparotomy Approach

With increasing experience, 2 distinct clinical situations likely to require CSLap were identified. The first indication included management of extensive graft strictures after failure of cervical mobilization to provide enough length gain to bridge the gap. In these patients, mobilization and pull-up of the transplant by CSLap was performed with the aim of

FIGURE 1. Rescue cervicosternolaparotomy for the treatment of long anastomotic stenosis (arrows) provided a 6-cm length gain, which enabled preservation of the primary conduit and redo of the pharyngocolonic anastomosis.

preserving the primary conduit (rescue CSLap) (Figure 1). As previously reported, strictures after esophageal reconstruction were divided in supra-anastomotic (located above the cervical anastomosis at pharyngeal level), anastomotic (located at the level of the cervical anastomosis), and diffuse (multiple, long segmental graft strictures).⁵ Endoscopic dilation was used as first-line treatment, and revision surgery was offered for strictures that were not eligible (>5 cm, >3 strictures) or had failed dilation (>5 attempts).⁵

The second indication for CSLap included situations in which exposure was necessary to obtain direct access to the retrosternal space; graft lengthening was not the issue in these circumstances. Exposure CSLap was performed for symptomatic (dysphagia, recurrent aspiration pneumonia) thoracoabdominal redundancy and graft perforation.

Preoperative Evaluation

A 3- to 6-month delay was considered mandatory between esophageal reconstruction and CSLap. Patient evaluation included dynamic barium swallow, upper gastrointestinal endoscopy and cervicothoracoabdominal computed tomography. If rescue CSLap was considered, otolaryngology evaluation with endoscopic assessment of vocal cord function was performed. Analysis of initial operative reports was performed by the team members during a dedicated preoperative surgical staff. Celiomesenteric arteriography was not undertaken. Elective CSLap was offered only to psychologically stable patients after careful psychiatric evaluation.

Technical Considerations

The patient was put on the operative table in a supine position with arms secured at his side, and a large operative field was prepared from the jaw to the pubis. The operation was always started by a comprehensive neck exploration through the previous cervical incision or by a median laparotomy to confirm that repair was not suitable by a limited approach. In case of stricture management, the cervical segment of the graft was dissected free; if length issues precluded the construction of a tension-free anastomosis, rescue CSLap was undertaken. Graft dissection through an abdominal approach initially was attempted during management of thoracic redundancy because the maneuver may allow intra-abdominal lowering of the redundant segment; exposure CSLap was undertaken in case of failure. The upper part of the graft was dissected free from the thoracic inlet, and the dissection was pursued between the anterior side of the graft and the posterior aspect of the sternum. Sharp dissection followed by blunt finger dissection of the substernal space was conducted caudally as far as possible. The abdomen was opened through the previous midline laparotomy, and complete dissection of the abdominal part of the transplant was undertaken before proceeding to sternotomy; during rescue, CSLap dissection of the graft vascular pedicle was always carried to its origin to increase length gain. Dissection of the lower end of the substernal space was started upward to join the neck dissection plane before starting bone transection; if this was not technically feasible, the anterior side of the transplant was released step by step from the posterior aspect of the sternum as the osteotomy progressed. At this point, no attempts were

FIGURE 2. CSLap during revision surgery for stenosis: Operative field (interrupted lines mark thorax limits).

made to dissect the lateral and posterior aspects of the graft to avoid vascular pedicle injury. Sternal division was performed with an oscillating saw after a vertical median incision between the sternal notch and the tip of the xiphoid. The osteotomy was performed from above downward or the other way around, depending on the surgeon's preference. If not done during the initial reconstruction, the sternoclavicular joint was systematically removed at the time of CSLap (Figure 2). The lateral sides of the graft were progressively dissected free from the lungs and mediastinal fat; eventually, the posterior aspect of the graft was freed from the anterior mediastinum, the pericardium, and the diaphragm. At the level of the diaphragmatic passage, the graft vascular pedicle usually lies on the posterior side and adheres strongly to the edges of the diaphragm; its identification during the abdominal dissection lowers the risk of vascular injury at this level.

During rescue CSLap, strictures and all scar tissues were excised after transplant release, and a new anastomosis was constructed in healthy tissues. If necessary, pharyngeal reconstruction was performed by the colopharyngoplasty technique.²¹ If attempts at transplant preservation failed (insufficient length gain, injury of the vascular pedicle), the graft was replaced by another conduit during the same operation.²²

During exposure CSLap, graft release was followed by the specific management of the retrosternal complication.⁵ Surgical treatment of graft redundancy consisted of entire graft mobilization followed by diversion or resection-anastomosis of the enlarged segment; the esophagocolic anastomosis was revised if strictured, and concomitant treatment of any point of partial obstruction (diaphragmatic hiatus, cologastric, or coloduodenal anastomosis stricture) was undertaken systematically.⁵ If exposure CSLap was performed to treat life-threatening complications (caustic reingestion, coloplasty perforation), patient survival prevailed over graft preservation and digestive continuity reconstruction.

After completion of the CSLap procedure, mediastinal and pleural tubes (24F-26F) were placed through stab incisions in the epigastrium and thorax. A rubber drain was left close to the cervical anastomosis. A feeding jejunostomy was systematically constructed at the end of the procedure. An aspiration nasocolic tube was pulled down into the graft to prevent transplant distension. Closure of the sternotomy was performed using 3 to 6 thick absorbable stitches; care was taken to obtain tight reapproximation of the sternal halves to favor bone healing. The pectoral fascia and subcutaneous fat were closed with running sutures. The skin was closed with clips.

Postoperative Management

Enteral nutrition by a jejunostomy tube was started after the return of bowel function. In the absence of operative complications, drainage tubes were removed on postoperative day 5 and oral feeding was started. Routine assessment of vocal cord function and barium swallow was not performed before initiating oral intake. If patients underwent concomitant pharyngeal reconstruction, a specific realimentation protocol was used as previously reported.²¹ Clinical evaluation was done every 4 months during the first 2 years and annually thereafter.⁵ Psychologic follow-up was pursued indefinitely.⁵

Statistical Analysis

Operative mortality and morbidity were defined as death or complications arising during the same hospital admission or before postoperative

day 90. Complications were graded according to the classification by Dindo and colleagues.²³ Late morbidity was defined as complications occurring after postoperative day 90. Self-sufficiency for eating and breathing was assessed in patients followed for more than 1 year after CSLap. Functional success was defined as the ability to remove jejunostomy and tracheotomy tubes in patients on an exclusive oral diet.

Results are reported as median [interquartile range] or as counts (proportion). In univariable analysis, categorical data were compared by the chi-square or Fisher exact test. For continuous data, the independent-samples *t* test or nonparametric Mann-Whitney test was used. Risk factors of failure to preserve the primary graft were identified with a binary logistic regression. All tests were 2 sided at the .05 significance level. All statistical analyses were performed using SPSS version 22.0 (IBM, New York, NY).

RESULTS

Patients

CSLap was performed in 55 (55%) of 100 patients who underwent revision surgery for graft dysfunction across the study period, whereas repair through a limited approach was performed in 45 patients; there was no significant difference between the characteristics of patients who did or did not require CSLap (Table 1). There were 28 men (51%), and their median age was 43 years [35-57]. The caustic agent was ingested with suicidal intent in 52 patients (95%). Thirty-one patients (56%) had a psychiatric history of depression (*n* = 23) or schizophrenia (*n* = 8). Ingested agents were caustic soda-based alkalis in 50 patients (91%), strong acids in 4 patients (7%), and bleach in 1 patient (2%). Thirty-six (66%) were in-house patients, and 19 patients (34%) were referred for the treatment of graft-related complications.

Rescue Cervicosternolaparotomy Approach

Rescue CSLap was performed in 43 patients (78%) (Table 2). Median delay between primary esophageal reconstruction and rescue CSLap was 11 months [6-20]. Indication for rescue CSLap included the presence of supra-anastomotic stenosis in 11 patients (26%), anastomotic stenosis in 23 patients (54%), and diffuse stenosis in 9 patients (21%). Twenty-four patients (56%) had undergone unsuccessful treatment attempts before rescue CSLap. Endoscopic dilation was performed in the 19 patients (44%) amenable to dilation (median 6 [4-8] attempts/patient), and revision surgery was performed in 10 patients (23%). Six patients had undergone attempts to treat supra-anastomotic stenoses by cutaneous flaps (*n* = 1), delto-pectoral flaps (*n* = 2), and free jejunal grafts (*n* = 3). Three patients failed reconstruction of the cervical anastomosis by the cervical approach. One patient had undergone 2 major reconstructive procedures before referral. First, an ileocolic graft fed by the colica media pedicle was constructed 6 months after emergency esophagogastrectomy; intraoperative conduit ischemia occurred after graft ascension to the neck. The right colon was removed, and a left colonic substitute fed by the left colic pedicle was brought up to the neck during the same

TABLE 1. Clinical characteristics of patients who underwent revision surgery for caustic injury at the Saint-Louis Hospital

Variables	Whole population N = 100	No CSLap N = 45	CSLap N = 55	P value
Age (y)	40 [31-49]	35 [29-44]	43 [35-57]	.008§
Sex				.493‡
Female	46 (46)	19 (42)	27 (49)	
Male	54 (54)	26 (58)	28 (51)	
Psychiatric history	53 (53)	20 (44)	33 (60)	.121‡
Suicide intent	90 (90)	38 (84)	52 (94)	.108†
Ingested agent				NA
Strong acid	10 (10)	5 (11)	5 (9)	
Alkalis	87 (87)	39 (87)	48 (87)	
Bleach	3 (3)	1 (2)	2 (4)	
Emergency management				NA
Conservative treatment	17 (17)	15 (33)	2 (4)	
Laparotomy and jejunostomy	10 (10)	0	10 (18)	
Esophagectomy	13 (13)	4 (9)	9 (16)	
Gastrectomy	1 (1)	0	1 (2)	
Esophagogastrectomy	59 (59)	26 (58)	33 (60)	
Extend resection*	7 (7)	3 (7)	4 (7)	1†
Emergency tracheotomy	26 (26)	11 (24)	15 (27)	.748‡
Primary esophageal reconstruction				
Delay in reconstruction (mo)	6 [4-8]	5 [4-6]	6 [4-11]	.160§
Esophageal substitute				NA
Ileocolon	57 (57)	27 (60)	30 (54)	
Left colon	34 (34)	17 (38)	17 (31)	
Stomach	9 (9)	1 (2)	8 (14)	
Pharyngeal reconstruction	34 (37)	12 (30)	22 (41)	.254‡
Delay between esophageal reconstruction and CSLap (mo)	7 [5-17]	5 [4-6]	15 [7-47]	<.001
Pharyngeal reconstruction during CSLap (or No CSLap)	39 (39)	17 (38)	22 (40)	.821‡
Mortality	2 (2)	0	2 (4)	.5†
Severe morbidity	15 (15)	0	15 (27)	<.001‡
ICU admission	28 (28)	1 (2)	27 (49)	<.001‡
If ICU stay, duration stay (d)	10 [5-25]	6	11 [5-26]	.571
Duration of hospital stay (d)	18 [12-38]	13 [10-20]	30 [4-97]	<.001
Late morbidity	37 (37)	17 (38)	20 (37)	.940‡
Functional success	36 (80)	36 (80)	39 (85)	.841‡

Data are n (%) or median [interquartile range]. *CSLap*, Cervicosternolaparotomy approach; NA, not applicable; *ICU*, intensive care unit. *Emergency resection extended to organs other than the esophagus and stomach: duodenopancreas, small bowel, spleen, and colon. †Fisher exact test. ‡Chi-square test. §Independent-samples *t* test. ||Mann-Whitney *U* test.

operation. The postoperative course was complicated by the ischemic necrosis of the graft tip resulting in prolonged cervical leakage, conduit obliteration, and, eventually, inability to eat. A second reconstructive attempt was performed 4 months later with the aim of bridging the cervical gap with a free bowel graft; repeat intraoperative necrosis of harvested bowel segments (ileum: *n* = 2, jejunum: *n* = 1) led to procedure abortion and patient referral.

Exposure Cervicosternolaparotomy Approach

In 12 patients (22%), exposure CSLap was undertaken for the treatment of redundancy (*n* = 8), graft perforation (*n* = 2), and caustic reingestion (*n* = 2). Characteristics of patients undergoing exposure and rescue CSLap were similar (Table 1).

Eight patients underwent CSLap for redundancy. Median delay between primary esophageal reconstruction and exposure CSLap for redundancy was 148 months [71-299] (Table 3). CSLap was performed in an emergency setting because of spontaneous transplant perforation in 2 patients. In 1 patient, ulcer perforation of the gastroduodenal anastomosis resulted in peritonitis 9 years after right esophagocoloplasty. After completion gastrectomy, CSLap was required to gain access at the lower mediastinal part of the graft and restore continuity by a “Roux-en-Y” colojejunal anastomosis. The second patient presented with signs of mediastinitis 3 years after left esophagocoloplasty. Surgical exploration by CSLap revealed complete necrosis of the ascended colon with no obvious cause, and the graft was removed.

TABLE 2. Clinical characteristics of 55 patients who underwent cervicosternolaparotomy for caustic injury at the Saint-Louis Hospital

Variables	Rescue CSLap N = 43	Exposure CSLap N = 12	P value
Age (y)	42 [34-54]	48 [42-58]	.263§
Sex			.469‡
Female	20 (46)	7 (58)	
Male	23 (54)	5 (42)	
Psychiatric history	25 (58)	6 (50)	.615‡
Suicide intent	40 (93)	12 (100)	1†
Ingested agent			NA
Strong acid	2 (5)	2 (17)	
Alkalis	41 (95)	9 (75)	
Bleach	0	1 (8)	
Emergency management			NA
Conservative treatment	2 (5)	0	
Laparotomy and jejunostomy	6 (14)	4 (33)	
Esophagectomy	7 (16)	2 (17)	
Gastrectomy	0	1 (8)	
Esophagogastrectomy	28 (65)	5 (42)	
Extend resection*	3 (7)	1 (8)	1†
Emergency tracheotomy	12 (28)	3 (25)	1†
Primary esophageal reconstruction			
Delay in reconstruction (mo)	6.8 [4-12]	4.5 [4-11]	.214§
Esophageal substitute			NA
Ileocolon	23 (53)	7 (58)	
Left colon	15 (35)	2 (17)	
Stomach	5 (12)	3 (25)	
Pharyngeal reconstruction	18 (42)	4 (33)	.744‡

Data are n (%) or median [interquartile range]. *CSLap*, Cervicosternolaparotomy approach; NA, not applicable. *Emergency resection extended to organs other than the esophagus and stomach: duodenopancreas (n = 2), small bowel (n = 3), spleen (n = 2), and colon (n = 1). †Fisher exact test. ‡Chi-square test. §Mann-Whitney U test.

Caustic reingestion motivated CSLap in 2 patients 12 months and 46 months after esophageal reconstruction. Both survived nonoperative management of the caustic reingestion episode. One of them developed a left pleural empyema 18 months after reingestion and underwent CSLap after repeat failure of radiologic drainage. The colonic graft transformed in a fibrous cord was removed during the procedure, and the empyema did not recur. The second patient developed severe graft strictures 3 months after reingestion, and endoscopic dilation was attempted. Perforation occurred during dilation and conservative management failure prompted emergency CSLap, mediastinal drainage, and graft removal. Further reconstruction was not reconsidered in these 2 patients.

Intraoperative Course

Median operative time was 500 minutes [interquartile range, 465-600]. During rescue CSLap, the primary conduit was preserved in 32 patients (74%) (Table 3). The median length gain obtained by transplant release in

TABLE 3. Intraoperative characteristics and postoperative outcomes of 55 cervicosternolaparotomy procedures performed at the Saint-Louis Hospital

Variables	Rescue CSLap N = 43	Exposure CSLap N = 12	P value
Delay between esophageal reconstruction and CSLap (mo)	11 [6-20]	107 [39-299]	.001‡
Intraoperative graft management			NA
Graft preservation	32 (74)	8 (66)	
Graft replacement	11 (26)	2 (17)	
Graft ablation	0	2 (17)	
Pharyngeal reconstruction during CSLap	22 (51)	1 (8)	.009
Mortality	1 (2)	1 (8)	.392†
Morbidity	28 (65)	7 (58)	.740*
Grade III/IV	12 (28)	3 (25)	1†
Reoperation	8 (19)	2 (17)	1†
Postoperative graft necrosis	1 (2)	0	NA
Pneumonia	19 (44)	5 (42)	.876*
ICU admission	21 (49)	6 (50)	1†
Duration of ICU stay (d)	15 [5-30]	9 [5-14]	.365‡
Duration of hospital stay (d)	31 [16-64]	25 [17-43]	.734‡
Late morbidity	16 (37)	3 (25)	1†
Functional success	33 (85)	6 (86)	1†

Data are n (%) or median [interquartile range]. *CSLap*, Cervicosternolaparotomy approach; NA, not applicable; *ICU*, intensive care unit. *Chi-square test. †Fisher exact test. ‡Mann-Whitney U test. Late morbidity was defined as complications occurring after postoperative day 90.

these patients was 8 cm [interquartile range, 5-10], enabling reconstruction of the cervical anastomosis. Concomitant pharyngeal reconstruction was performed at the time of rescue CSLap in 22 patients. Attempts at transplant preservation failed in 11 patients (26%) (Table 4). Failure was due to inability to gain sufficient additional lengths to redo the cervical anastomosis; no injury to the transplant vascular pedicle occurred. These patients underwent removal of the primary conduit and secondary reconstruction with a gastric (n = 1), bowel (n = 3), right colonic (n = 2), and left colonic (n = 5) substitute. In univariable analysis, failure to preserve the primary conduit during rescue CSLap was associated with lack of previous pharyngeal reconstruction ($P = .028$) and the presence of diffuse stenosis ($P < .004$). There was a trend for previous surgical repair attempts ($P = .053$) and female sex ($P = .052$), but figures did not reach statistical significance (Table 4).

CSLap allowed graft exposure in all 8 patients who required surgical revision for redundancy. Treatment included graft dissection, resection of the length excess, and colocolonic anastomosis in 6 patients; colocolonic bypass in 1 patient; and replacement of the gastric tube by

TABLE 4. Risk factors of failure to preserve the primary graft in 43 patients who underwent rescue cervicosternolaparotomy during revision surgery for stenosis: Univariate analysis

Variables	Success N = 32	Failure N = 11	P value	OR	95% CI	P value
Age (y)	43 [34-60]	38 [26-50]	.429§	0.968	0.919-1.019	.210
Sex			.043‡	0.225	0.050-1.016	.052
Female (ref)	12 (38)	8 (73)				
Male	20 (62)	3 (27)				
Psychiatric history	19 (59)	6 (55)	1†	0.821	0.206-3.266	.780
Suicide	29 (91)	11 (100)	.558†	2.514	0.525-12.036	.248
Ingested agent			1†	NA	NA	NA
Strong acid (ref)	2 (6.3)	0				
Alkalis	30 (93.8)	11 (100)				
In-house patients	13 (43.3)	7 (70)	.144‡	3.051	0.659-14.137	.154
Emergency management			.172‡	0.250	0.050-1.256	.092
Conservative (ref)	4 (13)	4 (36)				
Emergency surgery	28 (87)	7 (64)				
Extended* emergency resection	2 (6)	1 (9)	1†	1.500	0.123-18.363	.751
Esophageal substitute during primary reconstruction			NA			
Ileocolon (ref)	19 (60)	4 (36)				
Left colon	11 (34)	4 (36)		1.727	0.359-8.322	.496
Stomach	2 (6)	3 (28)		7.125	0.882-57.545	.065
Pharyngeal reconstruction during primary reconstruction	17 (53.1)	1 (9)	.014†	0.088	0.010-0.773	.028
Delay between primary reconstruction and CSLap (mo)	9 [5-19]	11 [7-160]	.338§	1.015	0.998-1.032	.077
Failed prior surgery	5 (16)	5 (46)	.092†	4.500	0.981-20.634	.053
Pharyngeal reconstruction during CSLap	19 (59)	3 (27)	.066‡	0.257	0.057-1.153	.076
Type of stricture			NA			
Supra-anastomotic	11 (35)	0		1	0.001-inf	1
Anastomotic (ref)	19 (59)	4 (36)				
Diffuse	2 (6)	7 (64)		16.625	2.472-111.799	.004

Data are n (%) or median [interquartile range]. OR, Odds ratio; CI, confidence interval; NA, not applicable; CSLap, cervicosternolaparotomy approach. *Emergency resection extended to organs other than the esophagus and stomach. †Fisher exact test. ‡Chi-square test. §Mann-Whitney U test. ||Binary logistic regression.

a colonic graft in 1 patient. This last patient also underwent pharyngeal reconstruction.

Postoperative Course

Two patients (4%) died in the postoperative period (Table 3). A 46-year-old woman died of multisystem organ failure secondary to aspiration pneumonia 10 days after rescue CSLap of an anastomotic stricture. The second patient, a 58-year-old man developed severe aspiration pneumonia and died 21 days after resection of gastroplasty redundancy. Postoperative complications were recorded in 35 patients (64%) and were severe (grade $\geq$ III) in 15 patients (27%). The most frequently recorded complication was postoperative pneumonia, which occurred in 24 patients (44%). Tracheotomy was performed in 19 patients (44%) undergoing rescue CSLap and 5 patients (42%) undergoing exposure CSLap. Eight patients (14.5%) experienced postoperative anastomotic leakage. The only postoperative graft necrosis occurred in the patient who was referred after 2 failed consecutive reconstruction attempts. CSLap release of the left coloplasty did not provide enough lengths to reach the neck and perform pharyngeal

reconstruction. In the absence of other possibilities, lengthening of the graft pedicle (artery and vein) with a venous graft was attempted. Massive fecal discharge through the sternotomy on postoperative day 3 revealed extensive graft necrosis prompting reoperation and graft removal. The patient survived after 2 months of intensive care unit management of an open mediastinum. No other sternal disjunction was recorded.

Twenty-seven patients required intensive care unit management (median length of stay, 11 days [5-26]). Median in-hospital stay was 30 days [4-97]. Ten patients (18%) required reoperation for the treatment of mediastinal abscess (n = 5), subcutaneous abscess (n = 2), graft necrosis (n = 1), and unexplained deterioration of the general condition (n = 2). Operative outcomes were similar after rescue and exposure CSLap (Table 3). Morbidity rates and in-hospital stay were reduced in patients who did not require CSLap during revision surgery (Table 1).

Late Outcomes

Late morbidity was recorded in 19 patients (35%) and included cervical anastomotic strictures (n = 11), abdominal redundancy (n = 1), glottic stricture requiring definitive

tracheotomy ($n = 1$), recurrent aspiration pneumonia ($n = 2$), severe diarrhea ($n = 3$), and open mediastinum ($n = 1$). Ten of 11 strictures (89%) were successfully managed by endoscopic dilatation (median of 2 [1-4] attempts/patient).

Median follow-up after CSLap was 4.4 years [11 months to 8 years], and 2 patients were lost to follow-up. Eventually, the functional outcome was evaluated in 46 patients and was successful in 39 patients (85%); functional success was recorded in 36 of 45 patients (80%) who underwent revision surgery for graft dysfunction without CSLap ($P = .841$). After rescue CSLap, functional success rates were similar in patients with (success: 25/30 patients; 83.3%) or without (success: 5/6 patients; 83.3%) initial graft preservation ($P = 1$).

DISCUSSION

The present study reports the outcomes of cervicosternolaparotomy performed at the time of revision surgery for graft dysfunction in patients with caustic injury. Approximately half of the revision surgery procedures performed across the study period included a CSLap. The main study findings were the low mortality (4%), acceptable severe morbidity (27%), and high functional success (85%) rates of CSLap. Of note, these figures compare favorably with results of primary esophageal reconstruction for caustic injuries in the literature.^{5,6,24} Intraoperative vascular pedicle injury never occurs, and with the exception of 1 patient in whom the lengthening of the graft vascular pedicle failed, subsequent graft necrosis was not observed. The need to perform CSLap during revision surgery increased operative morbidity rates and lengths of hospital stay but had no influence on mortality, late morbidity, and functional success. The present results suggest that in experienced hands, CSLap is effective for the treatment of graft dysfunction after retrosternal esophageal reconstruction.

Identification of 2 distinct indications of CSLap has an important clinical implication. CSLap was performed for the treatment of graft strictures in 43 (78%) of the 55 patients to rescue the primary conduit and reconstruct the cervical anastomosis. Prior pharyngeal reconstruction increased the odds of primary conduit preservation. Pharyngeal reconstruction actually requires construction of very long primary conduits²¹; this excess length was probably beneficial during rescue CSLap. In contrast, previous surgical repair attempts could predict the inability to recover the primary conduit. Suboptimal anastomotic reconstruction, usually performed by a limited cervical approach, leads to additional length loss, which may compromise further reconstruction. Thus, when length issues occur during cervical dissection of caustic stenosis, CSLap should be performed during the same procedure. This finding suggests

that patients requiring revision surgery for graft dysfunction benefit from early referral to expert centers.

In their report, Wu et al¹⁸ concluded that the esophageal substitute could be mobilized and advanced up to 1.5 cm for anastomosis through a limited cervical approach; sternotomy allowed an additional length gain of 1 cm in 3 of their patients. They eventually recommended the use of free jejunal grafts, skin flaps, or other pedicle flaps to correct defects longer than 2.5 cm.¹⁸ In our experience, graft release by rescue CSLap allowed a median 8-cm length gain, which was enough to preserve the primary cervical anastomosis in 32 patients (75%). The extra length gain provided by CSLap when compared with sternotomy alone was probably due to the complete abdominal redissection of the graft vascular pedicle to its origin. As underscored by Wu and colleagues,¹⁸ the length of the vascular pedicle is the limiting factor for transplant mobilization. Despite the initial impression that tension of the pedicle is tight, complete dissection up to its origin always provided a major length gain in our experience; incomplete dissection during primary reconstruction and progressive loosening of the vascular pedicle over time are possible explanations.¹⁹ When CSLap did not allow recovery of the primary conduit, we preferred secondary esophagocoloplasty over other reconstructive options. This attitude was based on the favorable outcomes after secondary esophagocoloplasty for caustic injuries previously reported by our group.²² Half of the patients underwent pharyngeal reconstruction at the time of rescue CSLap by colopharyngoplasty; this is a supplementary argument for constructing another colonic graft, rather than using an alternative reparation technique (jejunal grafts, musculocutaneous flaps).²¹

The second indication for CSLap was the need to obtain direct access to the retrosternal space to treat graft-related complications; graft lengthening was definitely not the issue in this situation. Exposure CSLap was performed mainly for the treatment of colonic redundancy. Of note, CSLap was undertaken on an emergency basis in 4 patients for the management of spontaneous graft perforation and caustic reingestion-related complications; none of them died, and the primary conduit could be preserved in 1 patient. Retrosternal grafts can be quickly removed by blunt dissection in life-threatening circumstances; however, if reasonable chances to recover the transplant exist, CSLap exploration can be justified.

CONCLUSIONS

CSLap during revision surgery for graft dysfunction after esophageal reconstruction for caustic injuries is reliable, is associated with low morbidity and mortality, and has good results. Transplant release by CSLap provides significant length gain, enabling primary conduit preservation and redo of the cervical anastomosis in most patients. CSLap also offers

direct access and allows specific management of graft-related complications confined in the retrosternal space.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

References

- DeMeester TR, Johansson KE, Franze I, Eypasch E, Lu CT, McGill JE, et al. Indications, surgical technique, and long-term functional results of colon interposition or bypass. *Ann Surg.* 1988;208:460-74.
- Fürst H, Hartl WH, Löhle F, Schildberg FW. Colon interposition for esophageal replacement: an alternative technique based on the use of the right colon. *Ann Surg.* 2000;231:173-8.
- Gerzic ZB, Knezevic JB, Milicevic MN, Jovanovic BK. Esophagocoloplasty in the management of postcorrosive strictures of the esophagus. *Ann Surg.* 1990; 211:329-36.
- Popovici Z. A new philosophy in esophageal reconstruction with colon. Thirty-years experience. *Dis Esophagus.* 2003;16:323-7.
- Chirica M, Veyrie N, Munoz-Bongrand N, Zohar S, Halimi B, Celerier M, et al. Late morbidity after colon interposition for corrosive esophageal injury: risk factors, management, and outcome. A 20-years experience. *Ann Surg.* 2010;252:271-80.
- Knežević JD, Radovanović NS, Simić AP, Kotarac MM, Skrobić OM, Konstantinović VD, et al. Colon interposition in the treatment of esophageal caustic strictures: 40 years of experience. *Dis Esophagus.* 2007;20:530-4.
- Thomas P, Fuentes P, Giudicelli R, Reboud E. Colon interposition for esophageal replacement: current indications and long-term function. *Ann Thorac Surg.* 1997; 64:757-64.
- Bonavina L, Chella B, Segalin A, Luzzani S. Surgical treatment of the redundant interposed colon after retrosternal esophagoplasty. *Ann Thorac Surg.* 1998;65: 1446-8.
- de Delva PE, Morse CR, Austen WG Jr, Gaissert HA, Lanuti M, Wain JC, et al. Surgical management of failed colon interposition. *Eur J Cardiothorac Surg.* 2008;34:432-7.
- Deng B, Wang RW, Jiang YG, Gong T-Q, Zhou J-H, Lin Y-D, et al. Prevention and management of complications after colon interposition for corrosive esophageal burns. *Dis Esophagus.* 2008;21:57-62.
- Domreis JS, Jobe BA, Aye RW, Deveney KE, Sheppard BC, Deveney CW. Management of long-term failure after colon interposition for benign disease. *Am J Surg.* 2002;183:544-6.
- Strauss DC, Forshaw MJ, Tandon RC, Mason RC. Surgical management of colonic redundancy following esophageal replacement. *Dis Esophagus.* 2008; 21:E1-5.
- Jeyasingham K, Lerut T, Belsey RH. Revisional surgery after colon interposition for benign oesophageal disease. *Dis Esophagus.* 1999;12:7-9.
- Icard P, Marchand JP, Grossetti D, Houssin D. Last recourse reconstruction of the cervicothoracic esophagus: the free jejunal transplant. *Ann Chir.* 1989;43: 229-31.
- Lin YD, Jiang YG, Wang RW, Gong TQ, Zhou JH. Platysma myocutaneous flap for patch stricturoplasty in relieving short and benign cervical esophageal stricture. *Ann Thorac Surg.* 2006;81:1090-4.
- Ananthakrishnan N, Nachiappan M, Subba Rao KS. Island pectoralis major myocutaneous flap for pharyngo-oesophageal strictures prior to oesphagocoloplasty. *J R Coll Surg Edinb.* 2001;46:202-4.
- Su CY, Chiang YC. The fabricated radial forearm flap in pharyngolaryngeal surgery: saliva leakage and its prevention. *Br J Plast Surg.* 1995;48:212-7.
- Wu MH, Lai WW, Lin MY, Chou NS. Prevention and management of strictures after hypopharyngocolostomy or esophagocolostomy. *Ann Thorac Surg.* 1994; 58:108-11.
- Cattan P, Chiche P, Berney T, Halimi B, Aidan K, Celerier M, et al. Surgical approach by cervicosternolaparotomy for the treatment of extended cervical stenoses after reconstruction for caustic injury. *J Thorac Cardiovasc Surg.* 2001;122:384-6.
- Chirica M, Resche-Rigon M, Bongrand NM, Zohar S, Halimi B, Gornet JM, et al. Surgery for caustic injuries of the upper gastrointestinal tract. *Ann Surg.* 2012; 256:994-1001.
- Chirica M, de Chaisemartin C, Goasguen N, Munoz-Bongrand N, Zohar S, Cattan P, et al. Colopharyngoplasty for the treatment of severe pharyngo-esophageal caustic injuries: an audit of 58 patients. *Ann Surg.* 2007;246: 721-7.
- Chirica M, Vuarnesson H, Zohar S, Faron M, Halimi B, Munoz Bongrand N, et al. Similar outcomes after primary and secondary esophagocoloplasty for caustic injuries. *Ann Thorac Surg.* 2012;93:905-12.
- Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240:205-13.
- Hong PW, Seel DJ, Dietrick RB. The use of colon in the surgical treatment of benign stricture of the esophagus. *Ann Surg.* 1964;160:202-9.

Key Words: cervicosternolaparotomy, esophageal reconstruction, caustic injury, esophageal stricture, esophageal redundancy