BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

MODERN ENDOSCOPIC AND RECONSTRUCTIVE SURGICAL APPROACHES TO THE TREATMENT OF POST-CAUSTIC ESOPHAGEAL STRICTURES

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doi:https://doi.org/10.5281/zenodo.24050371

ABSTRACT Background. Caustic esophageal injury may cause extensive tissue damage, followed by fibrosis and the formation of cicatricial strictures, resulting in dysphagia, malnutrition, weight loss, and impaired quality of life.
Objective. To analyze contemporary diagnostic and therapeutic approaches to post-caustic esophageal strictures, focusing on endoscopic and reconstructive surgical techniques, their indications, limitations, and outcomes, and to propose a staged management algorithm.
Materials and Methods. A narrative review of clinical guidelines, observational studies, and systematic reviews indexed in PubMed, PubMed Central, and Google Scholar was conducted. A protocol for a retrospective clinical study was also developed.
Results. Endoscopic dilation remains the first-line treatment for most established caustic strictures. Refractory and anatomically complex strictures may require adjunctive endoscopic procedures or esophageal reconstruction using a gastric, colonic, or jejunal conduit.
Conclusion. Individualized, staged, multidisciplinary management, including nutritional rehabilitation and long-term follow-up, is essential for optimizing outcomes.
Keywords: esophagus, caustic injury, cicatricial stricture, dysphagia, endoscopic dilation, balloon dilation, bougienage, stenting, esophageal reconstruction.

1. INTRODUCTION

Chemical injury to the esophagus is an important issue in gastroenterology and surgery. It occurs after the ingestion of strong acids, alkalis, or other corrosive substances. The severity of injury depends on the concentration and amount of the substance, its physical state, the duration of exposure, and individual characteristics of the esophageal mucosa [1,2]. Burns in children are often accidental, whereas in adults they are more frequently intentional; this distinction also affects the need for follow-up and psychological support [3].

Strong alkalis cause liquefaction necrosis through the breakdown of proteins and lipids, whereas strong acids cause coagulation necrosis. However, both types of substances can produce deep tissue injury and transmural necrosis [1].

In the acute phase, the severity of the burn, the depth of necrosis, and the risk of perforation are the main concerns. In the late phase, the principal problem is fibrotic narrowing of the esophageal lumen. This makes the passage of food difficult and causes dysphagia. Cicatricial stenosis typically develops within the first few months after the burn. In some patients, multiple, long, and complex strictures develop and require repeated endoscopic procedures [1,3]. An increased risk of esophageal squamous cell carcinoma has also been reported decades after the injury; therefore, long-term follow-up is necessary [3].

The main methods used to treat esophageal strictures include balloon dilation, bougienage, endoscopic stenting, intralesional corticosteroid injection, endoscopic incision (stricturotomy), and reconstructive surgery. Selecting the optimal method requires a comprehensive assessment of the stricture's anatomical characteristics, the patient's overall condition, and the outcomes of previous treatments.

A single treatment strategy is not appropriate for all patients. Endoscopic and reconstructive surgical methods should therefore be considered complementary options within a staged treatment pathway. This review analyzes contemporary approaches to treating cicatricial strictures after chemical burns and proposes a stepwise treatment algorithm.

2. MATERIALS AND METHODS

2.1. Literature search and selection

This article combines a narrative literature review with the development of a protocol for future clinical research. Data were obtained from PubMed, PubMed Central (PMC), and Google Scholar (search date: to be specified).

The search used the following English keywords: "caustic esophageal injury," "post-caustic esophageal stricture," "esophageal dilation," "refractory esophageal stricture," "endoscopic treatment," "esophageal reconstruction," "esophagogastroplasty," and "colonic interposition."

The inclusion criteria were clinical guidelines, randomized studies, retrospective analyses, and systematic reviews addressing the treatment of benign esophageal strictures caused by chemical burns, with sources verifiable by DOI or PMID. The exclusion criteria were publications with unspecified sources, studies focused exclusively on malignant strictures, duplicate publications, and materials lacking sufficient clinical information.

2.2. Proposed clinical research project

A retrospective clinical study is proposed as the practical component of this work. It may include patients diagnosed with cicatricial stenosis following a chemical burn who were treated at a specialized institution. Patients will be divided into two groups according to the treatment received: Group I—patients who underwent endoscopic treatment; Group II—patients who underwent reconstructive surgery.

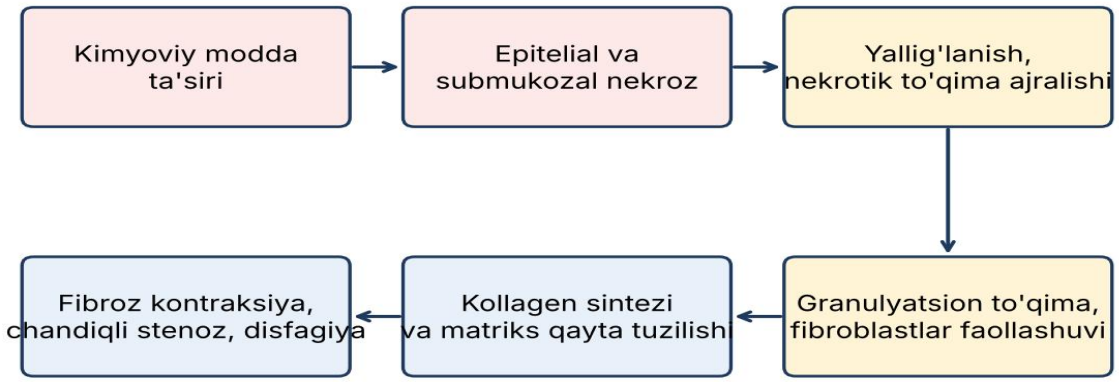
The following parameters will be assessed: age and sex, type of corrosive substance, location and length of the stricture, degree of dysphagia, number of endoscopic procedures, type of surgery, complications, nutritional status, stricture recurrence, and quality of life. The study must receive approval from the local ethics committee and be conducted in accordance with the STROBE recommendations.

Important note: This article does not report actual clinical patient data; therefore, no group sizes, statistical results, or treatment efficacy rates are presented.

3. RESULTS OF THE LITERATURE REVIEW

3.1. Pathogenesis of cicatricial stenosis and assessment of burn severity

When a chemical substance comes into contact with the mucosa, epithelial injury and inflammation develop first. As the injury deepens, the submucosa and muscular layers may also become involved. Subsequently, necrotic tissue sloughs off, granulation tissue forms, fibroblasts become activated, collagen synthesis increases, and the extracellular matrix is remodeled. As a result, the esophageal wall loses elasticity and the lumen narrows (Figure 1).



1-rasm. Kimyoviy kuyishdan keyingi chandiqli stenoz patogenezi (muallif sxemasi)

The endoscopic severity of the burn, graded according to the Zargar classification, is widely used to estimate the risk of stricture formation. The risk is significantly higher in grade 2b and grade 3 injuries [2–4]. The classification is presented in Table 1 and illustrated in Figure 2.

Table 1. Endoscopic classification of chemical burns (according to Zargar, based on literature [2,3])

Grade	Endoscopic appearance	Risk of stricture
0	Normal mucosa	No
1	Mucosal edema and hyperemia	Low
2a	Superficial ulcers, erosions, exudate, hemorrhages	Moderate
2b	Deep focal or circular ulcers	High
3a / 3b	Focal / widespread necrosis	High
4	Perforation	—

The main clinical manifestation of esophageal stricture is dysphagia. Initially, patients have difficulty swallowing solid food, followed by soft foods and, in severe cases, liquids. Weight loss and protein-energy malnutrition may develop as a result.

3.2. Clinical classification and diagnosis

The anatomical characteristics of the stricture are important when selecting a treatment strategy. Strictures may be classified by location (proximal, middle, or distal third); length (short or long); distribution (solitary, multiple, or diffuse); and response to treatment (dilation-responsive, recurrent, or refractory).

Refractory benign esophageal stricture is defined by failure to achieve the required functional diameter despite a standard course of dilation. According to a widely accepted definition, a stricture is considered refractory if a diameter of 14 mm cannot be achieved after at least five dilation sessions performed at two-week intervals. Recurrent stricture is defined as the inability to maintain the achieved diameter for four weeks [5,6].

Diagnostic investigations

Esophagogastroduodenoscopy (EGD) assesses the mucosa, the location of the stricture, and the degree of luminal narrowing. In the acute phase, it is usually performed within the first 24–48 hours [1,2]; in the late phase, it may be used in conjunction with dilation. Contrast esophagography demonstrates the length and shape of the narrowed segment and helps guide treatment planning in complex strictures. The radiological spectrum of late complications following corrosive injury has been described [7]. Computed tomography (CT) is important for evaluating the esophageal wall, mediastinal tissues, and surrounding structures, particularly when perforation is suspected. A complete blood count, electrolyte levels, serum albumin, and liver and renal function tests help assess the patient's general and nutritional status.

3.3. Endoscopic treatment methods

Endoscopic therapy is generally the initial treatment strategy for cicatricial strictures following chemical burns [1,5].

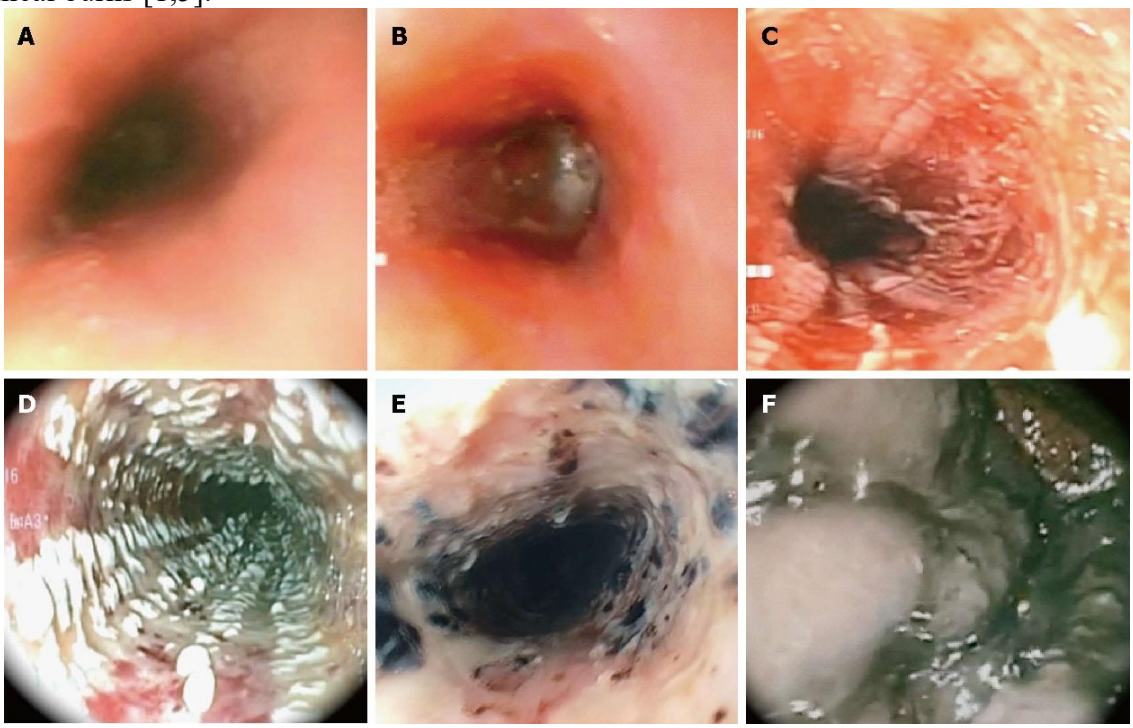


Figure 2. Endoscopic images illustrating Zargar grades 0 to IIIb. A: Grade 0, normal mucosa; B: Grade I, mucosal edema and erythema; C: Grade IIa, hemorrhage, erosions, blisters, and superficial ulcers; D: Grade IIb, circumferential bleeding and ulceration with exudate; E: Grade IIIa,

focal necrosis with deep gray or brownish-black ulcers; F: Grade IIIb, extensive necrosis with deep gray or brownish-black ulcers [25].

3.3.1. Balloon dilation

Under endoscopic guidance, a balloon catheter is positioned across the stricture and inflated under controlled pressure in accordance with the manufacturer's instructions. Advantages include minimal invasiveness, direct visual control, and the ability to perform dilation in a stepwise manner. Potential complications include perforation, bleeding, chest pain, and restenosis. The interval between procedures and the extent of dilation are determined by the characteristics of the stricture and the patient's clinical condition [5,8,9].

3.3.2. Bougienage

Bougienage is a method of mechanically dilating the esophageal lumen using specialized dilators. Savary–Gilliard dilators are widely used; they are passed through the stricture over a guidewire to achieve gradual dilation. Unlike balloon dilation, bougienage produces both radial and, to some extent, longitudinal forces. The safety of the Savary–Gilliard technique has been demonstrated in large case series [10]. Recommendations also provide guidance on progressively increasing the dilator size during a single session [11,12] (Figure 3).

Figure 3. Schematic illustration of magnet-assisted hydraulic bougienage superimposed on the anatomy of an infant with esophageal atresia [26].

Comparative studies of balloon and bougie dilation have not demonstrated a significant difference in effectiveness. However, these studies have mainly involved peptic and other benign strictures; their findings should therefore be applied cautiously to strictures caused by chemical burns [13–16]. The safety of dilation without fluoroscopic guidance has also been reported [17].

3.3.3. Endoscopic stenting

During stenting, an expandable prosthesis is placed within the narrowed segment. The main types include fully covered and partially covered self-expanding metal stents (FCSEMS and PCSEMS), plastic stents, and biodegradable stents. Stenting is not the first-line treatment for benign strictures following chemical burns because of the risks of migration, pain, erosion, and restenosis. It is therefore reserved for selected refractory cases [6,8].

3.3.4. Auxiliary endoscopic techniques

Intralesional corticosteroids may be administered together with dilation to reduce fibrosis, although evidence supporting their use in strictures caused by chemical burns is limited. Mitomycin C inhibits fibroblast proliferation and has been investigated for local application in selected complex strictures, but there is no clinical consensus on its routine use. Endoscopic stricturotomy may be considered for selected short, ring-shaped, or anastomotic strictures; caution is required in long and complex post-caustic strictures [6,18,19].

3.3.5. Complications of endoscopic treatment

Perforation is the most serious complication of endoscopic dilation. The risk depends on the dilation technique and the characteristics of the stricture; perforation is relatively uncommon in large case series [10,20]. Key measures to prevent complications include gradual dilation, caution when resistance is encountered, and monitoring for symptoms after the procedure [11,21].

3.4. Reconstructive surgical treatment methods

Reconstructive surgery is considered when endoscopic treatment is unsuccessful or when strictures are long, multiple, or anatomically complex. The aim of surgery is to restore the passage of food and enable adequate oral nutrition.

3.4.1. Esophagogastroplasty

The stomach is used as a conduit for esophageal replacement. The adequacy of its blood supply, length, and anatomical condition influence the success of the procedure. Potential complications include anastomotic leakage or stricture, reflux, conduit ischemia, and respiratory complications [22,23].

3.4.2. Esophagocoloplasty

When the stomach is severely damaged by the chemical injury or is otherwise unsuitable for reconstruction, a segment of the colon may be used. This approach can replace a long segment of the esophagus; however, it is technically complex, requires multiple anastomoses, and carries risks of ischemia and anastomotic leakage [22,23].

3.4.3. Jejunal interposition

Esophageal reconstruction may be performed using an isolated segment of jejunum. This technique is appropriate in selected anatomical and clinical situations. The length of the graft, its vascular supply, and the integrity of the anastomoses are important considerations [1,2].

When selecting a reconstructive procedure, the extent of esophageal injury must be assessed together with any chemical damage to the stomach and intestines [1,22,23]. Reis and colleagues conducted a comparative study of outcomes following esophagogastroplasty and esophagocoloplasty [23].

3.5. Comparative analysis of endoscopic and reconstructive surgical treatment

Table 2. Comparison of endoscopic and reconstructive surgical methods

Indicator	Endoscopic methods	Reconstructive surgery
Invasiveness	Relatively low	High
Main goal	Dilation of the stricture	Esophageal reconstruction
Anesthesia	Depends on the procedure (sedation or general)	General anesthesia
Recovery	Relatively quick	Longer
Repeat procedure	Often required	Possible
Major complication	Perforation	Anastomotic leakage
Scope of application	Most strictures suitable for dilation	Complex and refractory strictures

Endoscopic and surgical methods are not mutually exclusive alternatives; rather, they complement each other in different clinical situations.

3.6. Evaluation of Treatment Outcomes

An increase in luminal diameter alone is not a sufficient measure of treatment efficacy. Outcomes should be assessed using several parameters, including reduction in dysphagia severity, the ability to maintain oral intake, weight stabilization, albumin and other nutritional indicators, the need for repeat dilation, recurrence, postoperative complications, and quality of life. Dysphagia scales, such as the Ogilvie and Dakkak–Bennett scales, can help provide an objective assessment of clinical outcomes.

3.7. Nutrition and long-term follow-up

Protein-energy malnutrition associated with dysphagia directly affects treatment outcomes. Enteral nutrition options should therefore be evaluated, and a feeding gastrostomy or jejunostomy should be considered when necessary. Long-term follow-up should assess dysphagia, body weight, restenosis, and quality of life, as well as the risk of malignant transformation in the years following the burn [2,3].

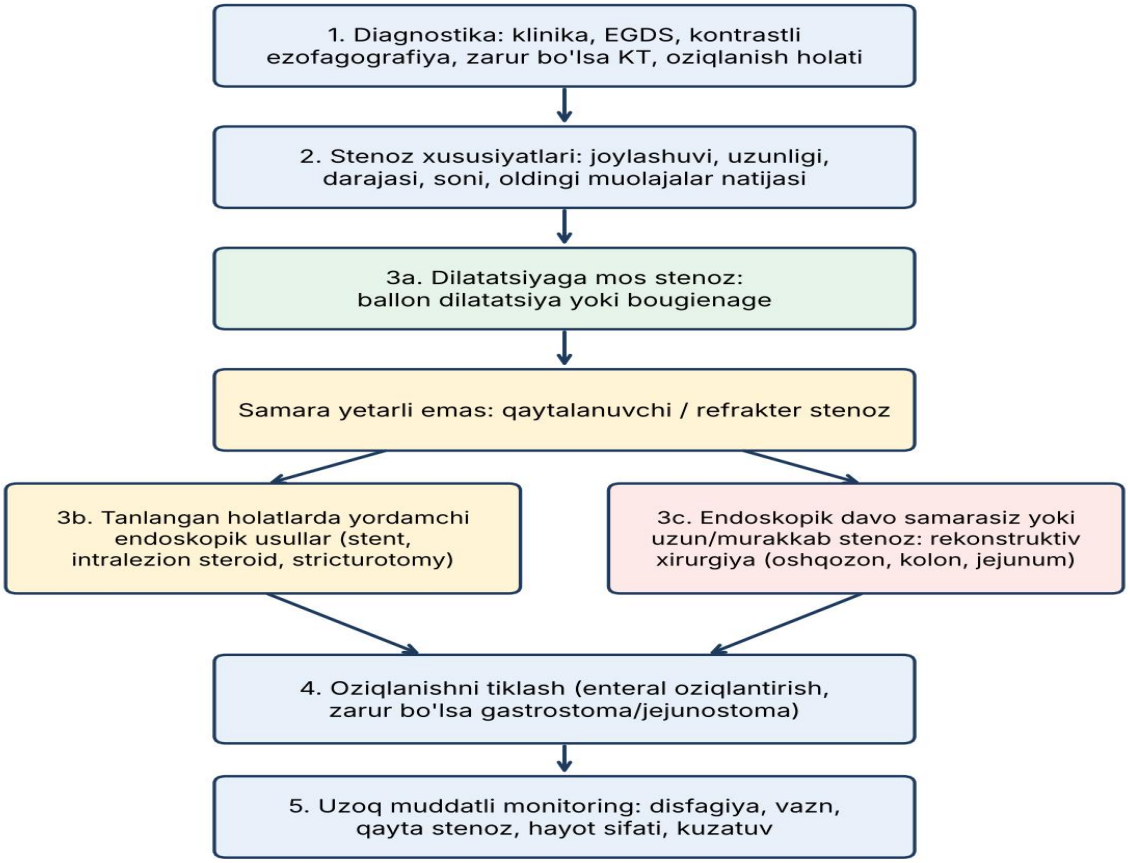
4. DISCUSSION

The literature review indicates that endoscopic dilation is the first-line treatment for cicatricial strictures following chemical burns. However, compared with peptic strictures, post-caustic strictures may be longer, more numerous, anatomically complex, and more prone to recurrence [3,16].

The WSES guidelines by Chirica and colleagues recommend endoscopic dilation as the primary treatment for strictures following chemical burns, with reconstructive surgery considered when repeated dilation is unsuccessful [1]. The British Society of Gastroenterology guidelines by Sami and colleagues discuss the role of dilation, intervals between procedures, the risk of perforation, and the management of refractory strictures [5]. A retrospective case series by Zhang and colleagues evaluated the feasibility of endoscopic treatment for caustic strictures; however, findings from a small cohort should not be generalized to all patients [24]. More recent recommendations on long-term management after caustic injury emphasize the importance of anatomical features, institutional capabilities, and the patient's condition when choosing between endoscopic and surgical approaches [2].

Gastric replacement is widely used in reconstructive surgery. When the stomach is severely injured or unsuitable, colonic interposition or jejunal reconstruction may be considered [22,23]. Evidence supporting adjunctive methods such as stenting, intralesional corticosteroids, and mitomycin C is largely based on small studies, many of which involve non-caustic strictures. Their use in post-caustic strictures should therefore be decided on an individual basis by a multidisciplinary team [6,8].

Overall, the most appropriate strategy is to begin with the safest suitable endoscopic treatment and proceed to reconstructive surgery in refractory or anatomically complex cases. Nutritional rehabilitation and long-term follow-up are integral parts of this approach (Figure 4).



2-rasm. Taklif etilayotgan davolash algoritmi (muallif sxemasi, validatsiya talab etadi)

4.1. Limitations of the review

First, this is a narrative review and does not follow a systematic search protocol such as PRISMA; therefore, selection bias is possible. Second, some cited sources concern peptic or other benign strictures rather than strictures caused by chemical burns. Third, the article contains no original clinical data, and the proposed algorithm requires prospective or retrospective validation.

4.2. Future research directions

Further research should include cohort studies using uniform criteria for caustic injuries, comparative studies evaluating different stent types and adjunctive treatments, and studies assessing quality of life with standardized scales.

5. PROPOSED CLINICAL TREATMENT ALGORITHM

The proposed algorithm is presented in Figure 4 and consists of five steps: (1) diagnosis; (2) assessment of stricture characteristics; (3) selection of treatment—balloon dilation or bougienage for suitable strictures, individualized adjunctive endoscopic techniques for recurrent or refractory strictures, and reconstructive surgery when endoscopic treatment is unsuccessful or anatomically unsuitable; (4) nutritional rehabilitation; and (5) long-term follow-up. The algorithm was developed by the authors on the basis of the literature review and requires validation before implementation in clinical practice.

6. CONCLUSION

Cicatricial stenosis following a chemical burn of the esophagus develops as a result of deep tissue injury, inflammation, fibroblast activation, and collagen deposition.

1. Effective treatment requires comprehensive assessment of the stricture's location, length, severity, anatomical complexity, and the patient's nutritional status.

2. Balloon dilation and bougienage are first-line procedures for most strictures that are suitable for dilation.

3. Stenting, intralesional corticosteroids, and other adjunctive techniques may be considered in selected refractory cases; however, evidence of their efficacy in post-caustic strictures remains limited.

4. If endoscopic treatment fails or the stricture is anatomically complex, esophagogastroplasty, esophagocoloplasty, or jejunal interposition may be considered.

5. Treatment efficacy should be assessed not only by the degree of anatomical dilation but also by dysphagia, the ability to maintain oral intake, body weight, restenosis, and quality of life.

6. An individualized, stepwise algorithm combining endoscopic and reconstructive approaches is a promising strategy for patient management.

There is no single universally applicable method for treating cicatricial strictures after chemical burns. Optimal outcomes depend on selecting endoscopic and reconstructive options according to the patient's anatomical and functional status.

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