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MINIREVIEWS

Endoscopic incisional therapy for benign esophageal strictures: Technique and results

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Abstract

Benign esophageal strictures refractory to the conventional balloon or bougie dilatation may be subjected to various adjunctive modes of therapy, one of them being endoscopic incisional therapy (EIT). A proper delineation of the stricture anatomy is a prerequisite. A host of electrocautery and mechanical devices may be used, the most common being the use of needle knife, either standard or insulated tip. The technique entails radial incision and cutting off of the stenotic rim. Adjunctive therapies, to prevent re-stenosis, such as balloon dilatation, oral or intralesional steroids or argon plasma coagulation can be used. The common strictures where EIT has been successfully used are Schatzki's rings (SR) and anastomotic strictures (AS). Short segment strictures (< 1 cm) have been found to have the best outcome. When compared with routine balloon dilatation, EIT has equivalent results in treatment naïve cases but better long term outcome in refractory cases. Anecdotal reports of its use in other types of strictures have been noted. Post procedure complications of EIT are mild and comparable to dilatation therapy. As of the current evidence, incisional therapy can be used for management of refractory AS and SR with relatively short stenosis (< 1 cm) with good safety profile and acceptable long term patency.

Key words: Endoscopic incisional therapy; Esophageal strictures; Anastomotic strictures; Needle knife; Radial incision and cutting

Core tip: Benign esophageal strictures refractory to conventional balloon or bougie dilatation can be subjected to endoscopic incisional therapy. The technique entails the use of needle knife or scissors for radial incision and cutting off of the stenotic rim. Adjunctive therapies with balloon dilatation or intralesional steroids may be needed for prevention of re-stenosis. Current evidence suggests use of incisional therapy for refractory short segment (< 1 cm) anastomotic strictures and Schatzki's rings with good safety profile and acceptable long term patency.

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INTRODUCTION

Benign esophageal strictures are a frequent challenge for the endoscopist. Peptic injury secondary to chronic acid exposure accounts for 80% of all benign esophageal strictures[1]. However, the remaining 20%-30% may be associated with Schatzki's rings (SR), esophageal webs, post radiation injury, anastomotic strictures (AS) and caustic ingestion. Based on anatomical complexity the strictures are classified as either simple or complex[2]. Simple are those with short, straight strictures, usually allowing passage of normal diameter endoscopes and are easy to treat (webs, rings and peptic strictures). The difficult to treat complex strictures are longer (> 2 cm), angulated or with severely stenosed lumen, a consequence of fibrosis with cicatricial narrowing. AS, caustic strictures and radiation strictures are known to be complex strictures[2]. Dilatation by bougie or balloon dilators has been the age old technique for management of benign esophageal strictures and generally the simple ones respond adequately to 1-3 dilatations[3]. The more difficult ones require more sessions of dilatations or the need for additional modes of treatment. Henceforth, Kochman *et al*[4] have defined strictures as: (1) refractory, when there was a persisting dysphagia score of 2 or more, as a result of inability to successfully achieve a diameter of 14 mm over 5 sessions at 2 wk intervals; and (2) recurrent, when there was inability to maintain a satisfactory luminal diameter for 4 wk once the target diameter of 14 mm had been achieved.

Although dilatation is a time tested, safe and effective mode of therapy for esophageal strictures, 10% of patients may require repeated dilatations[4,5] and 90% of those who have a single recurrence will eventually develop further recurrence. Moreover, dilatation failure group will require adjunctive modes of therapy. The various endoscopic options (Table 1) besides dilatation are intralesional steroid injection[6-8] or topical mitomycin C[9,10], esophageal stenting (self-expanding metal stents[11-13], self-expanding plastic stents[14,15] and biodegradable stents[16-19]), rendezvous procedure (antegrade and retrograde dilatation)[20,21] and incisional therapy.

Limited literature exists on endoscopic incisional therapy (EIT) and this review will deal with indications, techniques and the outcome of this modality in the management armamentarium of benign esophageal strictures.

DESCRIBED USES OF EIT

After the first description of its utility by Raskin *et al*[22] for Schatzki's ring in 1985, incisional therapy has been found to be useful in a number of other causes such as AS[23-25], strictures after esophageal endoscopic sub mucosal dissection (ESD) or endoscopic mucosal resection (EMR)[26,27], corrosive strictures[28], upper esophageal webs[29] and a host of other benign strictures.

Table 1 Endoscopic options of esophageal stricture management

Dilatation
Balloon
Bougie
Dilatation with injection therapy
Intralesional triamcinolone
Topical mitomycin C
Incisional therapy
Stent placement
SEMS
SEPS
Biodegradable stents
Rendezvous procedure

SEMS: Self expanding metal stents; SEPS: Self expanding plastic stents.

TECHNICAL DETAILS OF INCISIONAL THERAPY

Pre procedure assessment

Before subjecting a patient to EIT a proper assessment of the indication, the suitability of the procedure and the safety of the patient has to be done. The baseline symptom profile including the grade of dysphagia has to be recorded. Usually, strictures refractory to conventional modes of therapy are subjected to EIT as use of EIT for naive strictures (without prior dilatation therapy) has not been found to be superior to the conventional dilatation[30]. Active inflammation or underlying malignancy has to be ruled out with histology. Contrast esophagography and cross sectional imaging are needed for proper delineation of the stricture anatomy. The diameter of the stricture can be roughly estimated on endoscopy as: (1) size of 10 mm or more if a standard endoscope tip can be passed (GIF-H180 with insertion tube diameter of 9.8 mm; Olympus Medical Systems, Tokyo, Japan); (2) size of 5-10 mm if standard ultrathin scope can be passed (GIF-N180 with insertion tube diameter of 4.9 mm); (3) size of 2-5 mm if the ultrathin scope cannot be passed; and (4) less than 2 mm (pin point strictures) if the outer sheath of the needle-knife catheter (1.7-mm needle diameter) (Wilson Cook Medical Inc, Winston-Salem, NC) can just be passed or not pass through. The depth of the lesion is assessed by comparing with the length of the needle knife (approximately 4 mm). This documentation will help in outcome assessment post therapy. Finally, patients with bleeding diathesis, respiratory failure, severe or unstable cardiac disease and anastomotic leakage or infection need correction of these risk factors before therapy.

Instruments required

EIT has been carried with a host of electrocautery and mechanical devices including polypectomy snares and

Table 2 Instruments for incisional therapy

	Distal tip outer diameter (Fr)	Knife length (mm)	Knife diameter (mm)	Min. channel size (mm)	Working length (cm)
Needle knives					
Olympus (Tokyo, Japan)					
Triple lumen needle knife	5	5	0.2	2.8	195
Hook knife	Hook length 1.3 mm	4.5	0.4	2.8	165/230
Needle knife (require handle)					
KD-10Q-1.B	NA	3	0.4	2.0	195
KD-11Q-1.B	NA	3	0.7 (flat)	2.0	195
IT-Knife-L	Ceramic tip with diameter 2.2 mm	4	0.4	2.6	
Boston scientific (Natick, Mass)					
RX needle knife	5.5	5			200
Microknife™XL triple lumen knife	7-5.5				200
Cook medical (Winston Salem, NC)					
Fusion needle knife	6	4		4.2	200
Zimmon needle	5	7		2.0	200/320
Scissors					
Surgical scissors FS-3L-1 (Olympus): Min. channel size - 2.8 mm; Working length - 165 cm					
Heiss-Device flexible endoscopic scissors (Telemed Systems, Hudson, Mass): 1.7 mm blade diameter × 2.5 mm blade length; 1.7 mm shaft diameter; 180 cm shaft length; Single-action blade					
SB knife Jr (Sumitomo Bakelite Co., Tokyo, Japan): Width 4.4 mm × Length 3.5 mm; Rotatable monopolar scissors					

Fr: French; NA: Not applicable; IT knife: Insulated tip knife.

argon plasma coagulation[31]. However, the most widely used are the needle knives that are nothing but "naked" diathermy wires[32]. The standard needle knife designed for endoscopic retrograde cholangio-pancreaticography is a diathermy wire that protrudes out of the catheter sheath by a handle mechanism and electrocautery is done powered by electrosurgical generators. This free hand technique is a cause of concern for fear of perforation. To minimize this risk, a modification has been made with the addition of an insulated ceramic tip (insulated tip needle knife, IT knife) allowing only cutting at the side. Other modifications such as the hook tip knife can also be used[32].

Mechanical devices that have been used are the Heiss-Device flexible endoscopic scissors (Telemed Systems, Hudson, Mass) and the FS-3L-1, endoscopic suture scissors (Olympus America Corp, Melville, NY).

A combined mechanical and electrocautery device, originally devised for ESD, known as SB Knife Jr (Sumitomo Bakelite Co., Tokyo, Japan) has also been used. It is a scissor-type knife with rotatable monopolar scissors and insulated coating for enhanced incision power while protecting surrounding tissues. A comprehensive table of the various instruments with their specifications has been depicted in Table 2 and Figure 1.

The technique

First applied to SR, the most commonly used incisional therapy is the needle knife electroincision and will be dealt with in detail here. Although most commonly the standard needle knife is used, with the advent of various modifications, the IT-knife is preferred for short strictures[32]. The basic principle of this modality is the same as dilatation, *i.e.*, disruption or displacement of the fibrotic tissue to help restore a satisfactory lumen diameter and prevent the reorganization of the fibrotic tissue.

The electroincision requires use of radial incisions with the knife attached to an electrosurgical unit such as UES-30 generator (Olympus, Tokyo, Japan) or more commonly ERBE generator (Elektromedizin GmbH, Tübingen, Germany) with software controlled fractionated cuts either in the pure cut or blended cut modes.

The technique used has been essentially the application of radial incision of the stricture area and was rechristened with the term of "radial incision and cutting" (RIC) method by Muto *et al*[25] RIC is carried out in the following steps (Figure 2): (1) The stricture area is incised under direct vision with the needle knife in a radial fashion parallel to the longitudinal axis of the esophagus. Usually a virtual line connecting the cranial and the caudal sides of the lumen is presumed and the incision line is guided accordingly. Precise movement is imperative for appropriate use of needle knife and can be achieved better with the endoscope tip movement rather than the needle itself; (2) The length and the number of incisions are guided by the need to completely remove the rim of stenosis. On an average, 8-12 radial incisions are needed[24]. The incision depth is assessed using the needle-knife length as a comparator; (3) While for short segment strictures, the

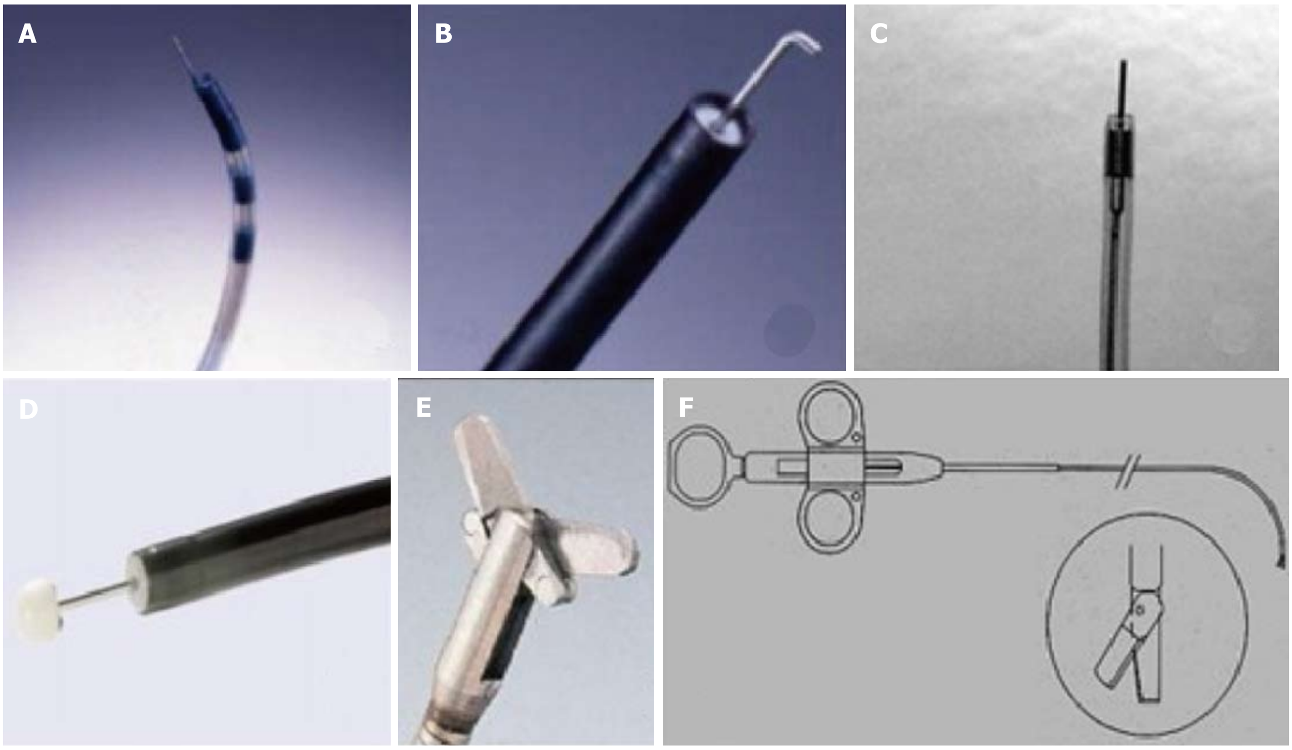

Figure 1 Accessories for incisional therapy. A: Triple lumen needle knife; B: Hook knife; C: Needle knife (KD 10Q); D: Insulated tip knife; E: Endoscopic surgical scissors (Image courtesy of Olympus); F: Heiss-Device flexible endoscopic scissors (image courtesy of Telemed systems).

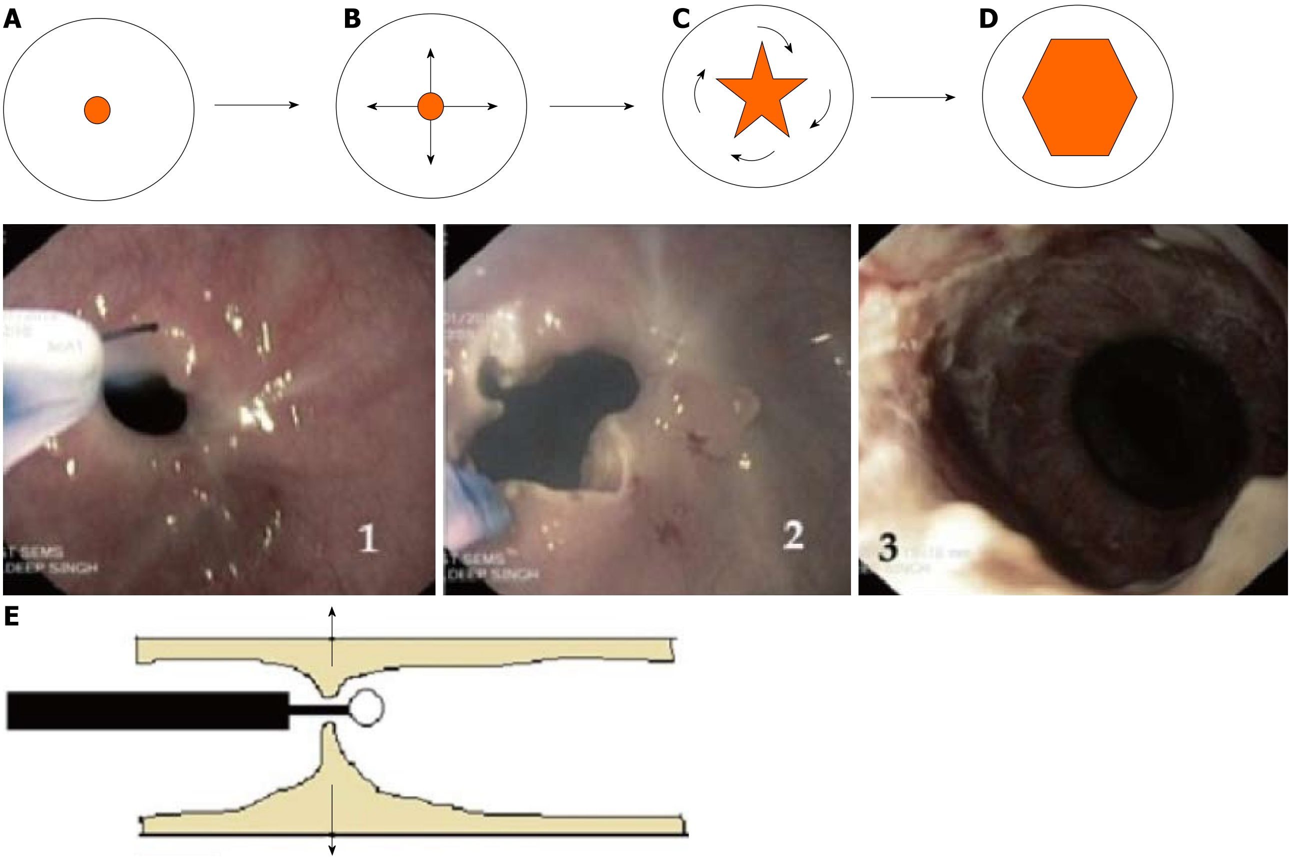

Figure 2 The technique of endoscopic incisional therapy procedure. A-D: Schematic front view of stricture site; B: Arrows depict the radial direction of incision; C: Curved arrows depict the slicing off of the intervening areas; D: Final outcome at the end of procedure; E: Lateral view of stricture site depicting the transverse working domain of the needle knife (arrows); 1: Use of needle knife for incision; 2: After radial incision; 3: At the end of EIT and balloon dilatation. EIT: Endoscopic incisional therapy.

technique is pretty straight forward, but for long segment ones, many times an opening needs to be created with multiple, short radial incisions before the scope can be negotiated for distal segments. Thus, technically difficult as it is for long segment ones, complete removal of the stenosed rim may not always be feasible; and (4) The parts of the strictured site in between the incision lines are then sliced off using the knife and the procedure is usually terminated once the scope can be easily passed across the strictured segment.

A modification to the technique proposed by Lee *et al*[24] was the use of a transparent hood attached to the scope tip for better visualization of the work field.

Post-procedure the patients are observed for immediate complications such as pain, significant bleeding or perforation. Once these have been ruled out, the patients can be discharged and assessed on a regular basis for recurrence of symptoms, grade of dysphagia or weight loss for which repeat assessment and redo of the therapy may be needed. Similar to the needle knife used for EIT various other devices such as the polypectomy snare[31] or scissors[28,33] have also been used.

Adjunctive measures

In the post-procedure phase, when the tissue has been freshly incised and chances of re-formation of stenosing fibrotic scar are high, various adjunctive measures have been described. Endoscopic balloon dilatation (EBD) with CRE balloon dilators (Boston Scientific, Natick, MA) have been done post-procedure and repeated frequently till the scarring of the cut surface[23,25,27]. Nonaka *et al*[28] have described the use of oral steroids for the prevention of re-stenosis. Yamaguchi *et al*[34] also demonstrated prevention of stricture after ESD with prednisolone. It has already been established in literature that use of intralesional steroids can prevent stricture recurrence[6-8]. The study of the efficacy of the same after EIT is currently being carried out in a large multi-center randomized control trial in Japan (UMIN Clinical Trials Registry: UMIN000014017). Argon plasma coagulation use has also been described along with incision for stepwise reduction of the scar tissue[31].

Evaluation of the treatment outcome

Recurrence of symptoms with dysphagia more than grade Ⅱ or the inability to pass a standard endoscope (9.5 mm) across the stricture site is considered as recurrent stenosis. If this condition arises even after 5 sessions of EIT, it is considered as treatment failure[30]. Post-procedure relief of symptoms, need for repeat procedure and the long term patency are factors assessed for the efficacy assessment of the procedure.

OUTCOME OF INCISIONAL THERAPY

The incisional therapy has been an alternate modality for the management of benign refractory strictures. The average time required for the procedure ranges from 6-14 min[24,25]. The majority of the published studies describe its use primarily in SR and AS. Anecdotal case reports have been found of its use in other conditions.

SR

After the first description of electrosurgical incision of SR by Raskin *et al*[22] in 1985, various studies have used it. When used as the initial intervention modality for SR (*i.e.*, without prior dilatation therapy), Guelrud *et al*[35] produced excellent results with 14 out of 17 patients (82.4%) becoming asymptomatic after a single session of EIT during a follow up of 46 mo. In the dilatation unresponsive group, Burdick *et al*[36] showed improvement in dysphagia in 6 out of 7 patients (85.7%) after a single session of EIT over a 36 mo follow-up, however later studies failed to replicate a similar outcome. DiSario *et al*[37] conducted EIT on 11 patients, who had a median of 3 dilatations prior to incision, out of whom 4 (36%) remained symptom free but 7 (64%) required further incisions or dilatations during a median follow-up of 55 mo. However, they found that there was a significant increase in the mean duration of improvement immediately after incision as compared with that of dilatation (17 mo *vs* 5 mo; $P = 0.034$).

In a prospective randomized study, comparing bougie dilatation with EIT as the initial therapy for symptomatic SR, Wills *et al*[38] demonstrated that both modalities had similar efficacy in symptom control, dysphagia and GERD, during a 12 mo follow-up period. However, the EIT group had longer symptom free survival time compared with the bougie dilatation group (7.99 mo *vs* 5.86 mo; $P = 0.03$).

AS

The most common esophageal stricture variant where EIT has been studied is the anastomotic stricture, mostly esophago-gastric anastomosis. Esophageal AS develops in 5%-46% of patients after surgical resection[2,39] and is secondary to post-operative complications such as bleeding, fistulization, leak development, anastomotic site infection and ischemia of the gastric anastomosis[2,39,40]. The success of balloon dilatation ranges from 70%-90% while 40% require more than 3 dilatations for optimal result[39-41]. A viable alternate management option has been the use of EIT as demonstrated in various studies (Table 3).

In cases of treatment naïve patients, after a single session of EIT, recurrence free course over a 6-24 mo follow up has been found to be 80.6% to 93%[24,30,31]. Thus, it is quite an effective therapy compared to dilatation without the need for repeated sessions for a considerable period of time. In fact, in a comparative trial with bougie dilatation, Hordijk *et al*[30] demonstrated that both EIT and dilatation were equally efficacious (80.6% *vs* 67.7%) at 6 mo follow-up.

In the more difficult group of refractory strictures, the symptom free rate dropped to 60% to 65%[25,42] with 44% requiring re-treatment. However, when

Table 3 Various studies of incisional therapy in esophageal anastomotic stricture

Ref.	Type of stricture	No. of patients	Length of stricture	No. of pre-procedure dilatations[1]	Follow-up duration (mo)	Outcome of single session
Schubert *et al*[31], 2003	Treatment naive	15	6.1 mm (3-10 mm)	NA	23	No recurrence - 14/15 (93%)
Simmons *et al*[23], 2006	Refractory	9	--	6	3-14	No dysphagia - 4/9 (44.4%) No response - 1/9 (11%)
Hordijk *et al*[42], 2006	Refractory	20	< 1 cm - 12 cm > 1 cm - 8 cm	8	12	No dysphagia - 12/20 (60%) Recurrence - 8/20 (40%) Treatment failure - 2/20 (10%)
[2]Hordijk *et al*[30], 2009	Treatment naive	EIT arm - 31 SB arm - 31	EIT arm - 1.35 cm SB arm - 0.55 cm (mean)	N/A	6	No difference in the success rate (80.6% *vs* 67.7%) Treatment failure- EIT arm - 1; SB arm - 5
Lee *et al*[24], 2009	Treatment naive	24	< 1 cm - 21 cm > 1 cm - 3 cm	N/A	24	No recurrence - 21/24 (87.5%) Restricture - 3/24 (12.5%)
Muto *et al*[25], 2012	Refractory	EIT - 32 EBD - 22	≤ 5 mm - 49 mm > 5 mm - 5 mm	10	EIT - 14.8 EBD - 17.2	Short term - 93.8% improvement Long term - EIT better than EBD

[1]Mean number of dilatations; [2]Randomized prospective study. Treatment naïve: No previous dilatation; EIT: Endoscopic incisional therapy; SB: Savary bougienage; EBD: Endoscopic balloon dilatation; NA: Not applicable.

compared to continued dilatation therapy, EIT performed better than dilatation with significantly higher patency rates at 6 mo (65.3% *vs* 19.8%, $P < 0.005$) and 12 mo (61.5% *vs* 19.8%, $P < 0.005$) follow-up[25].

The other most important contributor of EIT response is the length of the stricture. Hordijk *et al*[42] had demonstrated that while patients with stricture length less than 1 cm had recurrence free course, all patients with stricture length greater than 1 cm had recurrence. Similar finding has been shown by Lee *et al*[24] wherein only 4.8% patients with stricture < 1 cm had re-stricture as compared to 66.7% in the group with stricture > 1 cm. This has been attributed to the increased amount of fibrosis in the longer strictures and hence decreased response.

Other strictures

In a retrospective study of 8 patients with post chemo-radiotherapy, ESD or EMR induced strictures, EIT improved dysphagia in all patients in the immediate post-procedure phase but 3 mo lumen patency was seen in only 3 (37.5%) patients[26].

Anecdotal case reports of use of endoscopic scissors have been used for management of corrosive strictures[28] and fibrous scar in proximal esophagus[33]. Stricture after surgery for esophageal atresia in a 4-year-old child has also been reported to be managed with EIT along with stenting[43].

Author's experience

A total of 14 patients with benign esophageal strictures (AS 5, corrosive strictures 4) have been subjected to incisional therapy along with balloon dilatation. Incisional therapy was done with Microknife™ XL Triple lumen knife (Boston Scientific, Natick, United States) followed by balloon dilatation with CRE™ Balloon Dilator (Boston Scientific, Natick, United States). Successful dilatation was achieved in 11 of the 14 after 3-9 sessions. No complications were noted.

COMPLICATIONS

Complications of EIT include pain, bleeding or perforation. Perforation is the most dreaded complication and can occur because of inability to gauge the depth of the esophageal wall or the length of the stricture during the incision therapy. Bleeding is usually self-limited and lesser known complication as the fibrotic strictures subjected to incisional therapy are relatively avascular. The complication rate of EIT appears to be mild comparable to dilatations with bougies or balloons, which can have perforation or significant hemorrhage at a rate of 0.1% to 0.4%[3]. For EIT, the reported perforation rate ranges from 0%-3.5%[24,25,30,37,42] with no reported evidence of significant bleeding. Perforation can be managed essentially with conservative treatment and if it fails, can be subjected to stent placement or surgery. Bleeding can be easily managed with methods such as balloon tamponade. Thus, EIT is a safe therapeutic option for stricture management.

CURRENT STATUS OF INCISIONAL THERAPY

As of the current evidence, EIT can be used as a treatment modality for refractory SR and AS with relatively short stenosis (< 1 cm). A suggested algorithm for the management of benign strictures has been shown in Figure 3.

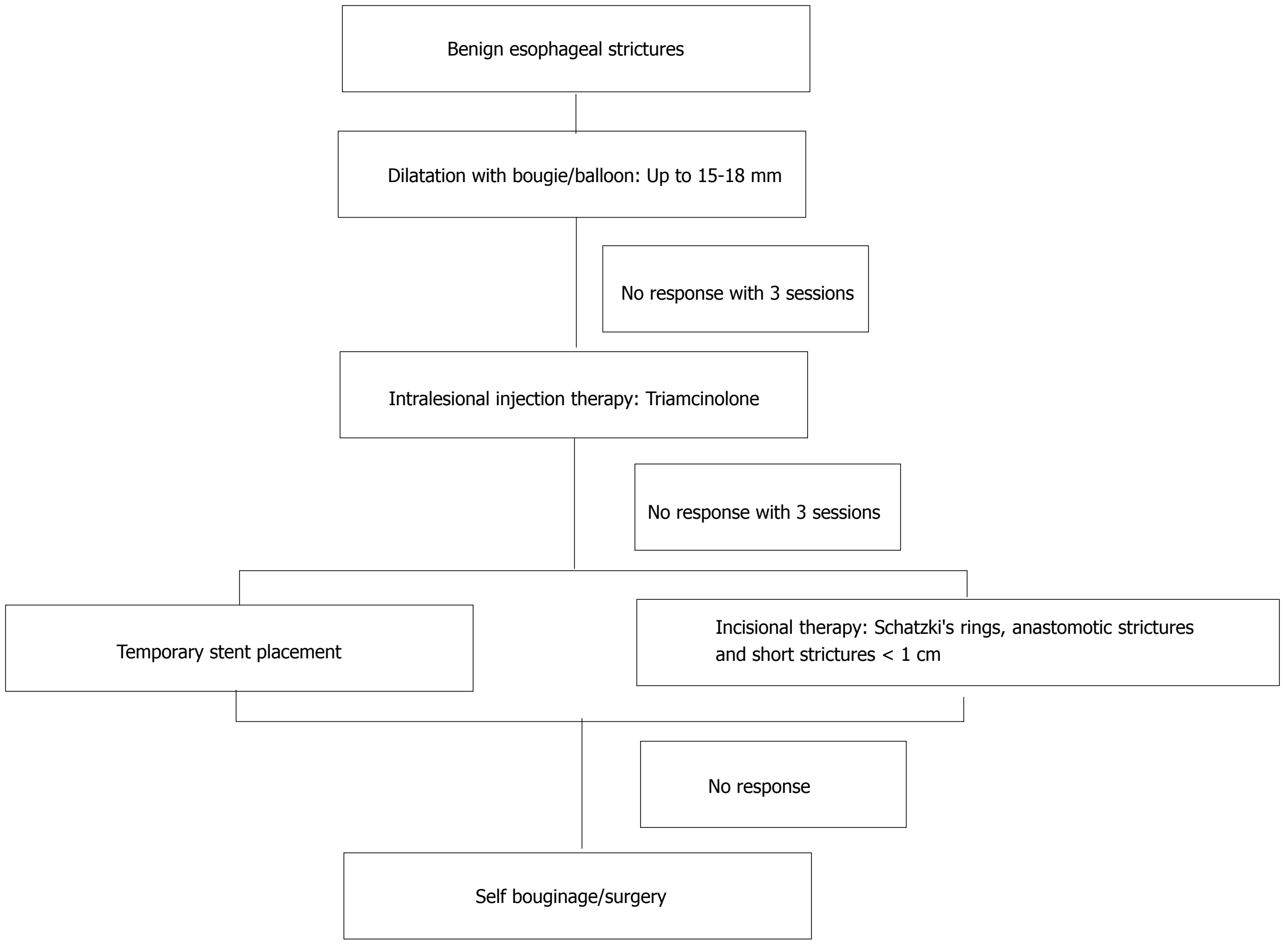

Figure 3 Algorithm for the management of benign esophageal strictures.

AREAS OF FUTURE RESEARCH

A number of questions need to be answered through larger trials before a standardized recommendation can be made regarding the use of incisional therapy in esophageal stricture management: (1) it can be used for all refractory strictures; (2) number of balloon or bougie dilatations before considering EIT; (3) cumulative risk of the procedure; (4) efficacy and applicability of instruments other than needle knife; (5) the choice of adjunctive therapy to prevent re-stenosis; (6) cost effectiveness of the therapy in the long run; and (7) technical expertise and applicability issues in day-to-day practice.

CONCLUSION

EIT is a feasible, safe and effective treatment modality for benign short refractory esophageal strictures with established evidence in SR and AS. It has good immediate symptom improvement with acceptable long-term patency.

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