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Technical Guidelines for Autologous Skin-Grafting Surgery to Prevent Stenosis Following Super Minimally Invasive Resection of Large-Area Esophageal Lesions

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Abstract: Autologous Skin-Grafting Surgery after Super Minimally Invasive Resection (ASGS-SMIR) is a novel endoscopic repair technique developed under the guidance of the Super Minimally Invasive Surgery (SMIS) concept. Based on previous clinical research results and combined with the ten core treatment principles of SMIS, this guideline systematically elaborates on the indications, contraindications, preoperative evaluation, surgical operation standards, postoperative management, and efficacy evaluation system of ASGS-SMIR. This surgery achieves effective repair of large-area mucosal defects and stenosis prevention in the esophagus through the technical process of "skin flap harvesting, mesh processing, sleeve suture, and stent fixation". The purpose of this guideline is to promote the standardized and normalized application of this technique and provide guidance for clinical practice.

Keywords: Esophageal stenosis; Super minimally invasive surgery; Autologous skin flap transplantation; Technical standards; Therapeutic endoscopy

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1. Introduction

1.1. Background

Autologous Skin-Grafting Surgery after Super Minimally Invasive Resection (ASGS-SMIR) is a novel endoscopic repair technique developed under the guidance of the Super Minimally Invasive Surgery (SMIS) concept for preventing stricture after extensive endoscopic resection of large esophageal lesions. Based on preliminary clinical research and integrating the ten core principles of SMIS, this standard systematically elaborates the indications,

contraindications, preoperative evaluation, surgical procedural standards, postoperative management, and efficacy evaluation system for ASGS-SMIR. Utilizing a technical process characterized by "skin harvesting, meshing, oversleeve suturing, and stent fixation", ASGS-SMIR achieves effective repair of large esophageal mucosal defects and prevention of stricture. The establishment of this standard aims to promote the standardized and normative application of the technique, providing guidance for clinical practice.

1.2. Establishment of technical standards for ASGS-SMIR under the SMIS framework

With the continuous development of digestive endoscopy technology, super minimally invasive surgery (SMIS) has become an important direction for the treatment of early esophageal cancer and precancerous lesions [1–3]. For large superficial lesions with a lesion area exceeding 3/4 of the esophageal circumference or involving the entire circumference, the incidence of postoperative esophageal stenosis can be as high as 88–100%, seriously affecting patients' quality of life [4]. Therefore, it is necessary to provide preventive measures for postoperative stenosis after endoscopic resection (ER) of superficial lesions involving the entire esophageal circumference [5,6]. Data from previous clinical studies indicate that one important factor in preventing postoperative esophageal stenosis after endoscopic submucosal dissection (ESD) surgery is re-epithelialization [7–9]. ASGS-SMIR, as an innovative repair technique under the SMIS concept, effectively prevents postoperative stenosis by combining autologous skin grafting with endoscopic technology [10–14]. Based on the ten core principles of SMIS and combined with previous clinical practical experience, this specification establishes the technical standards for ASGS-SMIR to promote the standardized development, promotion, and application of this technique [15].

2. Indications and contraindications

2.1. Indications

(1) After undergoing complete circumferential endoscopic submucosal tunneling dissection (ccESTD) or circumferential endoscopic submucosal dissection (cESD) for esophageal lesions, a full-circumference or near-full-circumference mucosal defect is formed, with a longitudinal length of ≥ 5 cm.
(2) Preoperative assessment revealed no evidence of lymph node or distant metastasis (confirmed by EUS, CT, etc.).
(3) The patient is generally in good condition and can tolerate the surgery and postoperative recovery process.
(4) The patient has provided informed consent and demonstrates good treatment compliance.

2.2. Contraindications

(1) Presence of active infection or immune dysfunction
(2) Severe cardiopulmonary insufficiency, unable to tolerate prolonged endoscopic procedures or anesthesia
(3) Coagulation dysfunction, which still fails to meet the surgical requirements after correction
(4) Active dermatosis in the skin harvesting area of the thigh or insufficient skin supply due to previous surgery
(5) The patient refuses or is unable to cooperate with postoperative nutritional support and long-term follow up

3. Preoperative preparation

3.1. Multidisciplinary evaluation

Establish an MDT team consisting of gastroenterology, plastic surgery, and anesthesiology to jointly assess the

feasibility and plan of surgery.

3.2. Equipment and apparatus

(1) Endoscope system
Therapeutic endoscope with accompanying water supply system, transparent cap
(2) Electrosurgical equipment
High Frequency generator (such as VIO300D), Dual knife, TT knife, IT knife
(3) Transplantation materials
Humby dermatome, absorbable suture (VICRYL Plus 4-0)
(4) Support system
Fully covered esophageal stent (FCES, such as Cook EVO-FC series), endoscopic clip (such as Micro-Tech clip)
(5) Nutritional support
Nasal jejunal feeding tube

3.3. Patient preparation

(1) Improving preoperative examinations
Blood routine, coagulation function, electrocardiogram, chest CT, gastroscopy + EUS
(2) Skin preparation
Select the outer side of the right thigh as the skin harvesting area and prepare the skin
(3) Fast for 8 hours and refrain from drinking water for 4 hours before the operation
(4) Sign the informed consent form for surgery

4. Surgical operation specifications

4.1. Operation principles

The ASGS-SMIR procedure must adhere to the core principles of SMIS: the principle of preserving organs and functions, the principle of maintaining cavity integrity, the principle of prioritizing sterility, the principle of avoiding chemical stimulation, the principle of preferring natural cavities, the principle of following the nearest approach, the principle of having hemostatic measures in place, the principle of having measures to seal perforations, and the principle of tumor-free and metastasis prevention.

4.2. Surgical steps

The surgical steps were illustrated in the schematic diagram below (see **Figure 1**).

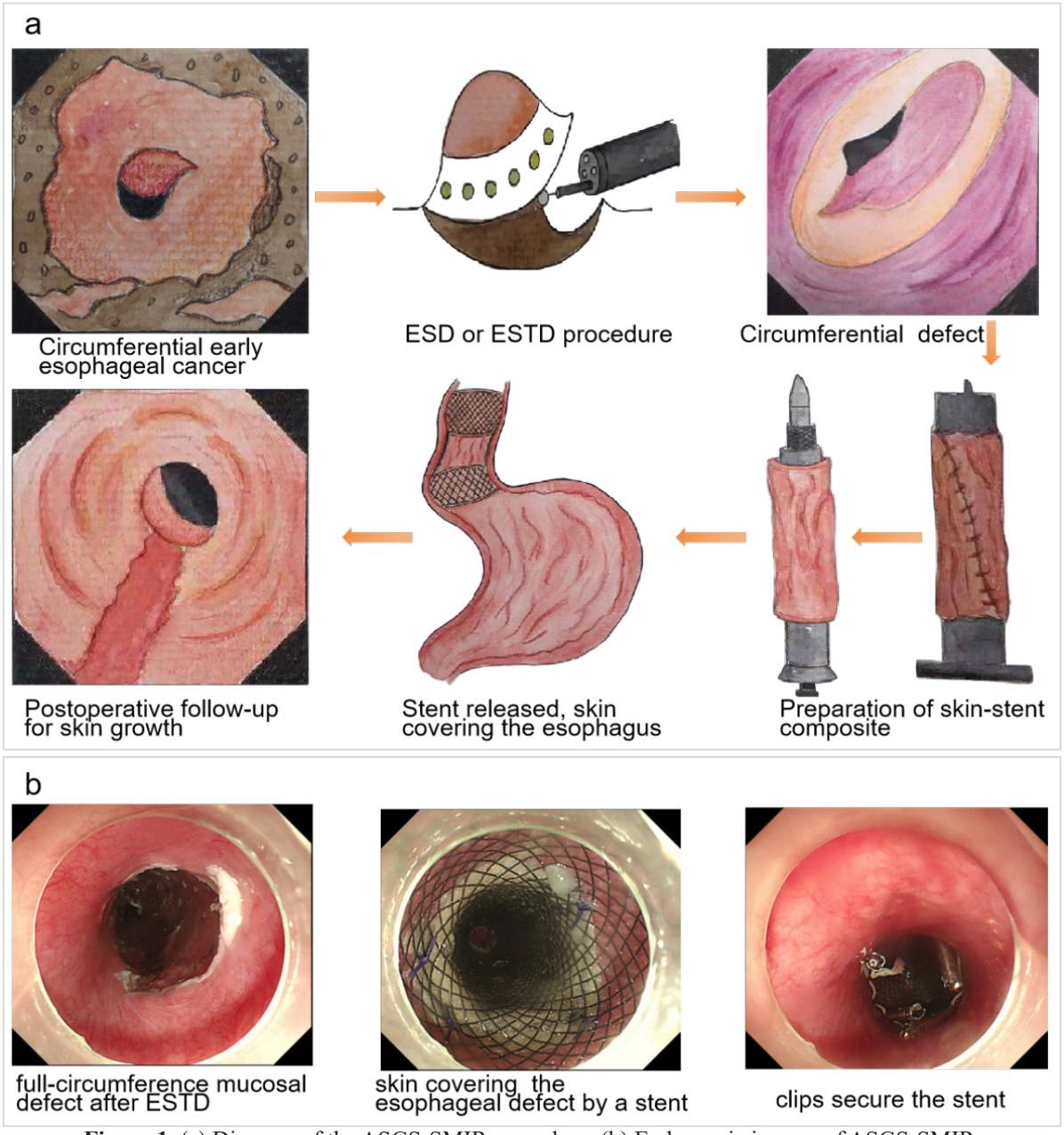

Figure 1. (a) Diagram of the ASGS-SMIR procedure; (b) Endoscopic images of ASGS-SMIR.

(1) Lesion resection

Perform ccESTD/cESD according to standard procedures to completely remove the lesion and form a circumferential surgical wound.

(2) Skin flap harvesting and processing

A medium-thick skin graft (thickness 0.3–0.5 mm) is harvested from the lateral side of the right thigh by a plastic surgeon. The size of the skin graft should be 10–15% larger than the area of the esophageal ulcer. The skin graft is made into a mesh shape with a surgical knife (with a hole spacing of about 5 mm). The skin graft is sutured into a "sleeve-like" structure using absorbable sutures.

(3) Preparation of flap-stent composite system

Fully release FCES *in vitro*; carefully cover the "sleeve-like" skin graft on the outer surface of FCES; ensure that the skin graft adheres closely to the stent without wrinkles or twists.

(4) Stent placement and fixation

Place the stent with a skin graft through the mouth; confirm the position of the stent under endoscopy (both ends should extend 2 cm beyond the edge of the ulcer); use endoscopic clips to fix the proximal end of the stent to the esophageal wall (usually 3–4 clips are required); place a nasojejunal feeding tube.

(5) Treatment of skin donor site

The skin donor site on the thigh is covered with vaseline gauze and bandaged with compression.

4.3. Intraoperative precautions

(1) Always keep the surgical field clear, and perform timely irrigation and suction
(2) Ensure that the skin graft is tightly fitted to the stent to prevent wrinkles
(3) Secure the stent accurately to prevent displacement
(4) Monitor the patient's vital signs closely
(5) Communicate with anesthesiologists about the patient's condition in a timely manner

5. Postoperative management

5.1. Recent management

(1) Nutritional management

Postoperative fasting for 7 days, with enteral nutrition administered through a nasogastric tube; starting from the 8th day, gradually transitioning to liquid diet → semi-liquid diet → soft diet

(2) Pharmacotherapy

Intravenous PPI (such as esomeprazole 40 mg q12h) for 5 days, followed by oral PPI for 8 weeks; Intravenous antibiotics for 3 days

(3) Complication monitoring

Closely observe for complications such as bleeding, perforation, infection, and stent migration.

5.2. Prevention and treatment of complications

(1) Bleeding

For active bleeding during surgery, electrocoagulation or clamping is the preferred method for hemostasis; for delayed bleeding, emergency endoscopic treatment should be the first choice

(2) Perforation

During the operation, timely detection and correction of the operation are necessary to avoid major perforation; for postoperative perforation, a chest CT scan is required to clarify the situation, and conservative treatment or surgical repair should be selected according to the situation

(3) Stent migration

Adjustment or replacement under endoscopy

(4) Transplantation failure

Enhance nutritional support, and perform secondary intervention if necessary

(5) Infection in the skin grafting area

Regular dressing changes and antibiotic treatment

5.3. Efficacy evaluation and follow up

5.3.1. Healing evaluation

(1) Technical success

The stent-flap complex was accurately placed and fixed, with no severe complications after surgery

(2) Therapeutic success

No stenosis requiring intervention (inaccessible by standard endoscopy) at 3 months postoperatively

5.3.2. Follow-up protocol

(1) 4–6 weeks after surgery: Endoscopy to assess the survival of the skin flap and remove the stent

(2) 8 weeks, 6 months, and 12 months after surgery: regular endoscopic follow-up

(3) After that, have a gastroscopy review once a year

5.3.3. Follow-up content

(1) Evaluation of flap survival rate

Evaluate the survival rate segment by segment per centimeter and calculate the overall survival rate

(2) Stenosis assessment

The Mellow-Pinkas swallowing function score is used to assess the improvement of quality of life

(3) Pathological confirmation

Biopsy was taken from the transplantation area, and it was confirmed to be squamous epithelium with hyperkeratosis

6. Conclusion

ASGS-SMIR, as an innovative repair technology under the SMIS concept, achieves effective repair of large-area mucosal defects and prevention of stenosis in the esophagus through standardized operating procedures and strict quality control. Its technical core, “skin flap harvesting, mesh processing, sleeve suture, and stent fixation”, ensures the safety and effectiveness of the surgery. The formulation of this specification provides a standardized basis for the promotion and application of ASGS-SMIR technology, which is conducive to promoting the development of esophageal disease treatment towards super minimally invasive and precise directions.

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Disclosure statement

The authors declare no conflict of interest.

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