International Journal of Biomedicine 15(2) (2025) 386-390
http://dx.doi.org/10.21103/Article15(2)_OA19

ORIGINAL ARTICLE

Surgery

INTERNATIONAL JOURNAL OF BIOMEDICINE

Sternocleidomastoid Muscle Flap Technique for Preventing Mediastinitis after McKeown Esophagectomy

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Abstract

Background: McKeown esophagectomy is a common surgical approach for treating esophageal cancer, but it carries a considerable risk of cervical anastomotic leakage. This complication may lead to descending mediastinitis and other serious infections. This study aims to evaluate the effectiveness of using the medial head of the sternocleidomastoid muscle (SCM) flap as a physical barrier to prevent anastomotic leakage from spreading into the posterior mediastinum.

Methods and Results: Anatomical and biomechanical models were developed to evaluate the vascular supply, mobility, and mechanical integrity of the SCM flap. A prospective clinical study was conducted in 17 patients undergoing McKeown esophagectomy using this technique. Anatomical modeling confirmed that the SCM flap could be mobilized and rotated without tension, allowing stable coverage of the anastomosis. Computational analysis showed even stress distribution and minimal tissue displacement (2.3±0.4 mm) during respiratory motion, indicating reliable fixation. Clinically, no cases of mediastinal contamination occurred. In all patients with leakage, the technique effectively localized the complication, preventing spreading to the mediastinum.

Conclusion: The use of the medial head of the sternocleidomastoid (SCM) flap effectively prevents descending mediastinitis and pleural empyema in cases of cervical anastomotic leakage following McKeown esophagectomy.(**International Journal of Biomedicine. 2025;15(2):386-390.**)

Keywords: McKeown esophagectomy • anastomotic leakage • descending mediastinitis • sternocleidomastoid muscle flap

For citation: Toneev EA. Sternocleidomastoid Muscle Flap Technique for Preventing Mediastinitis after McKeown Esophagectomy. International Journal of Biomedicine. 2025;15(2):386-390. doi:10.21103/Article15(2)_OA19

Introduction

McKeown esophagectomy is widely used to treat thoracic esophageal cancer, particularly for tumors located in the upper thoracic segment. However, one of its most significant complications is cervical anastomotic leakage. According to multiple sources, the incidence of this complication ranges from 11.4% to 21.2%, with mortality rates varying from 7.2% to 35%, depending on the severity of the infection.[1,2]

Managing patients with anastomotic leakage is complex and often requires extended hospitalization. It is important to distinguish between types of leakage: when a cervical leak results in an external fistula, conservative treatment typically suffices, including local wound care, nutritional support, and infusion therapy. In contrast, leaks that extend into the mediastinum may lead to descending mediastinitis, which has been reported to cause mortality in up to 50% of cases.[3]

Various preventive methods have been proposed to reduce the risk of mediastinal contamination. One strategy involves wrapping the anastomosis with vascularized tissue, such as an omental flap, which not only protects the site but also promotes healing.[4] Another approach is to use muscle flaps to physically separate the anastomosis from the mediastinum, which reduces the negative pressure gradient from the pleural cavity and prevents fluid migration. Among these, the transposition of the sternocleidomastoid muscle (SCM) flap to the border between the neck and the mediastinum has shown potential.[5]

This study evaluates the outcomes of applying the SCM flap to create a barrier between the anastomotic site and the posterior mediastinum.

Materials and Methods

This study was conducted in two phases: an experimental anatomical phase followed by a prospective clinical trial. The first phase aimed to validate the use of the SCM flap to prevent descending mediastinitis in cases of cervical anastomotic leakage. The second phase evaluated the clinical outcomes of

patients who underwent McKeown esophagectomy with the proposed method.

Experimental Phase

The anatomical study was carried out on five fresh cadavers without significant cervical or thoracic abnormalities. The specimens ranged from 43 to 69 years, with a postmortem interval of 24 to 48 hours. Cervical access was achieved through a left-sided incision along the SCM. The cervical esophagus was mobilized to assess whether the SCM flap could adequately cover the superior mediastinal aperture.

Detailed anatomical dissection was performed to analyze the vascular supply and topography of the SCM. Flap dimensions, including length, width, and thickness, were measured using digital calipers. Rotational capacity and the ability to provide tension-free coverage of the mediastinal inlet were assessed. A digital goniometer was used to record rotation angles, and the stretch coefficient was calculated through standardized load testing. Barrier function was evaluated based on the flap's conformity to the mediastinal contour and its ability to isolate the anastomosis. Optimal fixation methods were determined through testing of various suture techniques, followed by mechanical assessment using computational modeling.

Clinical Phase

The clinical component of the study included 17 patients who underwent McKeown esophagectomy between January 2023 and December 2024 at the Department of Thoracic Oncology, Regional Clinical Oncology Center, Ulyanovsk, Russia. A thoracoscopic approach was used for all cases, with port placement optimized for mediastinal dissection and lymphadenectomy in accordance with national guidelines. Abdominal access was obtained through an upper midline laparotomy. In all cases, a gastric conduit 3–4 cm in width was created from the greater curvature of the stomach. Mechanical stapling was followed by reinforcement with a continuous PDS 3-0 suture. Abdominal lymphadenectomy was completed at the D2 level. Cervical access was achieved along the medial border of the left SCM. An end-to-side, two-layer, hand-sewn anastomosis was performed between the esophagus and the posterior wall of the conduit. The isolation of the anastomotic site from the posterior mediastinum was achieved using the proposed technique. The medial head of the left SCM was mobilized, with its proximal end detached from the clavicle, and rotated posteriorly to serve as a barrier between the anastomosis and the mediastinum (Fig. 1).

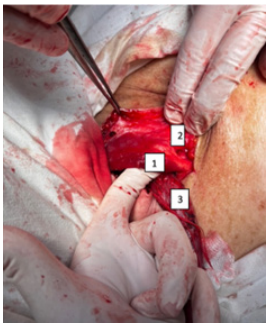

Fig. 1. *Mobilization of the Medial Head of the SCM*
1–Medial head of the sternocleidomastoid muscle
2–Lateral head of the sternocleidomastoid muscle
3–Resected esophagus

To stabilize the flap, its distal segment was anchored to the vertebral fascia using one or two U-sutures. This maneuver allowed the conduit to be moved forward and closer to the thyroid gland and surrounding neurovascular structures, minimizing the risk of dead space formation (Fig. 2,3).

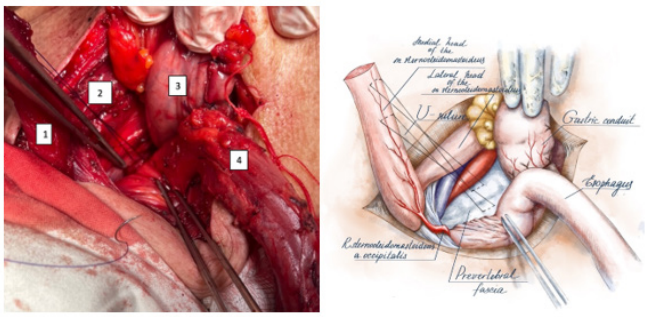

Fig. 2,3. *U-Suture Between the Prevertebral Fascia and the Distal Part of the Medial Head of the SCM*
1 – Medial head of the sternocleidomastoid muscle (SCM)
2 – Lateral head of the sternocleidomastoid muscle (SCM)
3 – Conduit from the greater curvature of the stomach
4 – Resected esophagus

A vacuum-assisted drainage system was inserted via a counterincision. Before drain placement, a 100 mL saline leak test was conducted to assess anastomotic integrity (Fig. 4). Skin closure was completed using interrupted sutures.

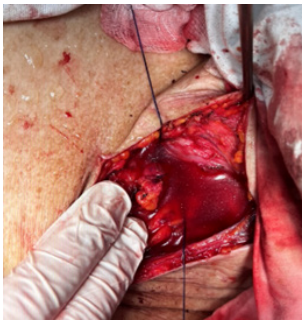

Fig. 4. *Leak Test of the Anastomotic Site for Isolation From the Posterior Mediastinal Space*

A 12Fr post-pyloric feeding tube was introduced into the conduit immediately after surgery to facilitate early enteral nutrition. Oral feeding was initiated on postoperative day 5, following multislice computed tomography (MSCT) to assess anastomotic integrity.

Tumor staging followed the 8th edition TNM classification by the Union for International Cancer Control (UICC).[7] Postoperative complications were categorized using the Thoracic Morbidity and Mortality (TMM) system,[8] while preoperative risk was assessed with the ASA physical status scale.[9] Anastomotic leakage was classified using the system proposed by Larburu Etxaniz S.[10]

Mechanical properties and stability of the SCM flap were further evaluated using finite element analysis (FEA) in ANSYS Mechanical software (ANSYS Inc., USA). Modeling incorporated anatomical data from the cadaveric study and simulated respiratory dynamics to assess stress distribution

and tissue displacement. Statistical analysis was conducted using StatTech v. 4.7.2 software (StatTech LLC, Russia).

Results

Anatomical Modeling

In the cadaveric phase, mobilization of the sternocleidomastoid (SCM) muscle was successfully performed in all five specimens. The average muscle length increased from 12.92±0.30 cm pre-mobilization to 15.76±0.27 cm post-mobilization, allowing for tension-free rotation and complete coverage of the superior mediastinal aperture. The mean width at the mid-third of the muscle was 3.24±0.11 cm, and the average thickness was 0.94±0.11 cm.

Vascular supply was consistently provided by the superior thyroid artery and the sternocleidomastoid branch of the occipital artery, with no anatomical variations that impeded muscle rotation. The mean rotation angle was 49.0±1.58°, enabling firm apposition to the anterior longitudinal ligament. The calculated stretch coefficient was 1.14±0.016.

The flap was fixed using two PDS 3-0 U-sutures to the prevertebral fascia. Stability was maintained during simulated respiratory excursions, with no observable tension or flap displacement. A contrast-enhanced leak test demonstrated complete sealing of the mediastinal inlet. Fixation to the anterior longitudinal ligament proved more stable compared to alternate methods, such as attachment to the SCM fascia or pretracheal fascia.

Computational Modeling

Finite element analysis (FEA) was conducted to assess the biomechanical performance of the SCM flap under physiological stress. Simulations incorporated anatomical and mechanical parameters, including muscle elasticity and fascia compliance. Intrathoracic pressure variations ranging from 10 to 40 cm H_2O were modeled to mimic respiratory dynamics (Fig. 5).

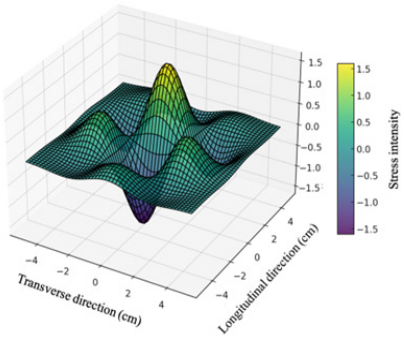

Fig. 5. *3D Model of Mechanical Stress Distribution on the Medial SCM Flap*

The analysis revealed that the highest mechanical stress occurred at the suture fixation points, primarily in areas where direct load transfer took place. In contrast, the central and distal portions of the flap experienced minimal tension, indicating effective load dispersion. Tissue displacement remained within safe thresholds (≤2.3±0.4 mm), supporting the flap's stability during dynamic conditions. These findings reinforce the flap's suitability for mediastinal isolation in postoperative settings.

Clinical Outcomes

Seventeen patients (mean age of 59.3±8.2 years) were included in the prospective clinical study. Key demographic and clinical parameters are summarized in Table 1.

Table 1.

Clinical characteristics of the study population.

Parameter	Category	n	%
Sex	Female	3	17.6
	Male	14	82.4
Chronic Kidney Disease	Present	4	23.5
	Absent	13	76.5
Diabetes mellitus	Present	6	35.3
	Absent	11	64.7
Charlson Index, Me	4.00 [2.00 – 4.00]		
BMI, Me	19.5 [17.0 – 23.8]		
Stage	IIA	3	17.6
	IIB	5	29.4
	IIIB	9	52.9
Tumor Location	Upper thoracic	1	5.9
	Middle thoracic	8	47.1
	Lower thoracic	8	47.1
Histological Type	Adenocarcinoma	5	29.4
	Squamous cell carcinoma	12	70.6

All patients underwent neoadjuvant therapy. Chemotherapy using the FolFox regimen was administered to 5 patients (29.4%), while 12 patients (70.6%) received chemoradiotherapy based on the CROSS protocol (a total dose of 45 Gy, with 1.8 Gy per fraction).

Anastomotic leakage occurred in 4 patients (23.5%). Type I leaks (n=2) were radiologically detected and resolved with conservative management. Type II leaks (n=2) required extended wound care but did not lead to systemic complications. No cases of descending mediastinitis or mortality were observed.

Hybrid surgical approaches were used in 12 patients (70.6%), while 5 patients (29.4%) underwent standard open McKeown procedures. Surgical parameters are presented in Table 2.

Table 2.

Surgical parameters.

Parameter	M±SD	95% CI
Operative time, min	333.5 ± 45.4	310.1 – 356.8
Blood loss, mL	414.7 ± 206.7	368.4 – 621.00

Postoperative imaging confirmed effective mediastinal isolation by the SCM flap in all cases. No instances of

conduit displacement or mediastinal leakage were identified. Postoperative computed tomography confirmed the absence of mediastinal leakage and the adequate positioning of the muscle flap for mediastinal isolation (Fig. 6).

Fig. 6. *Computed Tomography of the Cervical Region. Arrows indicate the positioning of the medial muscle flap for mediastinitis prevention.*

These findings support the technique's reliability in preventing mediastinal contamination, even in the event of anastomotic failure.

Discussion

McKeown esophagectomy remains a cornerstone in the surgical treatment of esophageal cancer, but cervical anastomotic leakage continues to pose significant challenges. Despite technical refinements, the risk of leakage and its complications, particularly descending mediastinitis, persists in a substantial proportion of patients.[11-14] The consequences of mediastinal contamination include increased morbidity, prolonged hospitalization, and, in severe cases, mortality.

Various methods have been proposed to prevent the spread of leakage into the mediastinum. The use of vascularized tissue flaps, such as omentum or muscle, has shown promise in reducing infection rates by creating a biological barrier.[15,16] However, omental flaps may be prone to ischemia and infection, especially when mobilized extensively.[17] Fixation of the gastric conduit directly to the prevertebral fascia has also been explored, but this approach can compromise microvascular perfusion, increasing the risk of anastomotic ischemia and necrosis.[18]

The technique evaluated in this study, which involves rotating the medial head of the SCM muscle, provides both mechanical and biological isolation of the anastomotic site. Our anatomical modeling demonstrated that the SCM flap could be reliably mobilized and rotated without tension. The average rotation radius was 4.4±0.16 cm, with a rotation angle of 49.0±1.58°, which enabled full coverage of the superior mediastinum without compromising blood flow.

Computational modeling reinforced these findings, showing that the highest mechanical stress was concentrated at the fixation site to the prevertebral fascia, while the remainder of the flap experienced minimal strain. Tissue displacement remained within 2.3±0.4 mm during simulated respiratory excursions, which supports the flap's mechanical stability under dynamic conditions.

Clinically, the SCM flap technique demonstrated its value. Among the 17 patients in this study, 4 developed cervical anastomotic leakage, yet none experienced descending mediastinitis or pleural empyema. This contrasts with previously reported mortality rates of up to 50% in cases where mediastinal contamination occurred.[3]

Comparable approaches have been described in the literature. For example, Yang et al.[19] proposed using a full SCM flap transected at the mastoid process to wrap around the anastomosis. While leakage rates remained unchanged, mediastinal spread was effectively prevented in their study. However, long-term outcomes related to esophageal strictures or swallowing dysfunction were not fully addressed.

Our results align with the broader body of evidence emphasizing the importance of protecting the anastomosis from negative thoracic pressure and bacterial contamination. The SCM flap provides a well-vascularized, mobile, and structurally stable option that integrates seamlessly into the surgical field. One limitation to consider is anatomical variability in SCM size and vascularization, which may limit flap viability in some patients.

Overall, this study supports the medial SCM flap as a safe and effective method for reducing the risk of mediastinal complications after McKeown esophagectomy, especially in high-risk patients with a potential for anastomotic leakage.

Conclusion

The use of the medial head of the sternocleidomastoid muscle flap effectively prevents descending mediastinitis and pleural empyema in cases of cervical anastomotic leakage after McKeown esophagectomy.

Competing Interests

The authors declare that they have no competing interests.

References

1. Duan X, Bai W, Ma Z, Yue J, Shang X, Jiang H, Yu Z. Management and outcomes of anastomotic leakage after McKeown esophagectomy: A retrospective analysis of 749 consecutive patients with esophageal cancer. Surg Oncol. 2020 Sep;34:304-309. doi: 10.1016/j.suronc.2020.06.002. Epub 2020 Jun 30. PMID: 32891347.

2. Toneev EA, Pikin OV, Aleksandrov OA. [Risk factors for anastomotic leakage following McKeown esophagectomy: a single-center retrospective analysis]. Grekov's Bulletin of Surgery. 2024;183(1):15-22. (In Russ.) doi: 10.24884/0042-4625-2024-183-1-15-22

3. Fabbi M, Hagens ERC, van Berge Henegouwen MI, Gisbertz SS. Anastomotic leakage after esophagectomy for esophageal cancer: definitions, diagnostics, and treatment. Dis Esophagus. 2021 Jan 11;34(1):doaa039. doi: 10.1093/dote/doaa039. PMID: 32476017; PMCID: PMC7801633.

4. Vetter D, Gutschow CA. Strategies to prevent anastomotic leakage after esophagectomy and gastric conduit reconstruction. Langenbecks Arch Surg. 2020 Dec;405(8):1069-1077. doi:

10.1007/s00423-020-01926-8. Epub 2020 Jul 10. PMID: 32651652; PMCID: PMC7686179.
5. Patent No. 2780133 C2 Russian Federation, IPC A61B 17/24. Method for Preventing Mediastinitis During the Formation of a Digestive Anastomosis in the Neck: No. 2022105333, filed on February 28, 2022, published on September 19, 2022. Authors: Toneev EA, Pikin OV, Ryabov AB [et al.]. Applicant: Federal State Budgetary Institution "National Medical Research Center of Radiology" of the Ministry of Health of the Russian Federation.
6. Yakovlev SV, Zhuravleva MV, Protsenko DN, et al. Antibiotic stewardship program for inpatient care. Clinical guidelines for Moscow hospitals. Consilium Medicum. 2017;19(7.1. Surgery):15–51. (In Russ.)
7. Rice TW, Patil DT, Blackstone EH. 8th edition AJCC/UICC staging of cancers of the esophagus and esophagogastric junction: application to clinical practice. Ann Cardiothorac Surg. 2017 Mar;6(2):119-130. doi: 10.21037/acs.2017.03.14. PMID: 28447000; PMCID: PMC5387145.
8. Seely AJ, Ivanovic J, Threader J, Al-Hussaini A, Al-Shehab D, Ramsay T, Gilbert S, Maziak DE, Shamji FM, Sundaresan RS. Systematic classification of morbidity and mortality after thoracic surgery. Ann Thorac Surg. 2010 Sep;90(3):936-42; discussion 942. doi: 10.1016/j.athoracsur.2010.05.014. PMID: 20732521.
9. Daabiss M. American Society of Anaesthesiologists physical status classification. Indian J Anaesth. 2011 Mar;55(2):111-5. doi: 10.4103/0019-5049.79879. PMID: 21712864; PMCID: PMC3106380.
10. Larburu Etxaniz S, Gonzales Reyna J, Elorza Orúe JL, Asensio Gallego JI, Diez del Val I, Eizaguirre Letamendia E, Mar Medina B. Fístula cervical postesofagectomía: diagnóstico y tratamiento [Cervical anastomotic leak after esophagectomy: diagnosis and management]. Cir Esp. 2013 Jan;91(1):31-7. Spanish. doi: 10.1016/j.ciresp.2012.09.005. Epub 2012 Nov 29. PMID: 23199473.
11. Low DE, Kuppusamy MK, Alderson D, Cecconello I, Chang AC, Darling G, Davies A, D'Journo XB, Gisbertz SS, Griffin SM, Hardwick R, Hoelscher A, Hofstetter W, Jobe B, Kitagawa Y, Law S, Mariette C, Maynard N, Morse CR, Nafteux P, Pera M, Pramesh CS, Puig S, Reynolds JV, Schroeder W, Smithers M, Wijnhoven BPL. Benchmarking Complications Associated with Esophagectomy. Ann Surg. 2019 Feb;269(2):291-298. doi: 10.1097/SLA.0000000000002611. PMID: 29206677.
12. Edmondson J, Hunter J, Bakis G, O'Connor A, Wood S, Qureshi AP. Understanding Post-Esophagectomy Complications and Their Management: The Early Complications. J Clin Med. 2023 Dec 11;12(24):7622. doi: 10.3390/jcm12247622. PMID: 38137691; PMCID: PMC10743498.
13. Yin Q, Zhou S, Song Y, Xun X, Liu N, Liu L. Treatment of intrathoracic anastomotic leak after esophagectomy with the sump drainage tube. J Cardiothorac Surg. 2021 Mar 23;16(1):46. doi: 10.1186/s13019-021-01429-7. PMID: 33757562; PMCID: PMC7988901.
14. Toneev EA, Charyshkin AL, Martynov AA, Firstov AA, Danilova LA, Anokhina EP, Zaripov LR. Dislocation of the Cervical Anastomosis toward the Mediastinum after McKeown Esophagectomy: A Single-Center Retrospective Study. International Journal of Biomedicine. 2024;14(2):335-337. doi:10.21103/Article14(2)_ShC
15. Liu B, Ma H, Liu X, Minervini F, Rao M, Campisi A, Cheng J, Xing W. Effect of sternocleidomastoid flap repair and endoscopic injection of emulsified adipose tissue stromal vascular fraction in the treatment of refractory cervical anastomotic leak contaminating mediastinum. J Thorac Dis. 2024 Apr 30;16(4):2668-2673. doi: 10.21037/jtd-24-442. Epub 2024 Apr 29. PMID: 38738227; PMCID: PMC11087614.
16. Yoshida N, Eto K, Matsumoto T, Kosumi K, Imamura Y, Iwatsuki M, Baba Y, Miyamoto Y, Watanabe M, Baba H. Omental Flap Wrapping Around the Esophagogastric Anastomosis and Association with Anastomotic Leak in Esophagectomy for Esophageal Cancer: A Propensity Score-Matching Analysis. J Am Coll Surg. 2023 Jan 1;236(1):189-197. doi: 10.1097/XCS.0000000000000454. Epub 2022 Dec 15. PMID: 36205406.
17. Goense L, Meziani J, Ruurda JP, van Hillegersberg R. Impact of postoperative complications on outcomes after oesophagectomy for cancer. Br J Surg. 2019 Jan;106(1):111-119. doi: 10.1002/bjs.11000. Epub 2018 Oct 29. PMID: 30370938.
18. Chernousov AF, Khorobrykh TV, Vetshev FP, Osminin SV, Chesarev AA. [Surgical treatment in patients with locally advanced and metastatic esophageal cancer]. P.A. Herzen Journal of Oncology. 2018;7(4):15-19. (In Russ.) https://doi.org/10.17116/onkolog20187415
19. Yang L, Hong Z, Lin Z, Chen M, Yang X, Lin Y, Lin W, Zhu J, Xie S, Kang M, Zhang Z, Lin J. Efficacy of sternocleidomastoid muscle flap in reducing anastomotic mediastinal/pleural cavity leak. Esophagus. 2023 Jan;20(1):89-98. doi: 10.1007/s10388-022-00946-1. Epub 2022 Jul 28. PMID: 35900684.

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