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IDEAS AND INNOVATIONS

Reconstructive

Use of the Intercostal Artery-based Latissimus Dorsi Muscle for Intrathoracic Reconstruction after Division of the Thoracodorsal Vessels and Latissimus Dorsi Muscle

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Summary: The latissimus dorsi muscle is the workhorse flap for intrathoracic reconstruction. Prior thoracotomy, which divides the latissimus dorsi muscle, limits the muscle's intrathoracic reach. We present our experience using the distal portion of the muscle for intrathoracic reconstruction based off an intercostal vessel. We also demonstrate the ability of this intercostal perforator to allow for chimeric flap elevation with a separate skin paddle, depending on the branching pattern of the intercostal vessels. This study provides a case series of three consecutive patients, treated between September 2021 and June 2022. The intrathoracic pathology addressed in these patients are bronchopleural fistula, aortoesophageal fistula, and bronchoesophageal fistula. All patients had the resolution of symptoms related to intrathoracic fistulae and did not experience recurrence. This novel pedicled muscle flap can be an additional option for patients with prior thoracotomy and avoids the morbidity which can be seen with the serratus or rectus abdominis muscle flaps. *(Plast Reconstr Surg Glob Open 2023; 11:e5074; doi: 10.1097/GOX.0000000000005074; Published online 20 June 2023.)*

INTRODUCTION

Plastic and reconstructive surgeons are frequently called upon by other specialties to provide intrathoracic reconstruction for complex thoracic pathology.[1–4] Due to its size, length, and location, the latissimus dorsi represents the primary muscle flap solution for intrathoracic reconstruction. Unfortunately, in patients who have had a prior nonmuscle-sparing thoracotomy, the latissimus dorsi muscle is usually divided. In these patients, the distal part of the muscle can no longer be transposed to an intrathoracic position based off the thoracodorsal vessels.[5] In this subset of patients, alternative flaps, such as the serratus anterior muscle flap or omentum flap, need to be considered. Utilizing these flaps for intrathoracic reconstruction comes with the inherent risk of diaphragmatic hernia (when the omentum is used) and the possibility of winging of the scapula (with serratus anterior). Here, we report a novel use of the remaining distal latissimus dorsi muscle following thoracotomy; this technique allows safe harvest of the remaining distal muscle based on a perforating branch of an intercostal vessel. The resulting pedicle length allows for intrathoracic transposition and reconstruction of bronchopleural and tracheal defects. The intercostal perforators allow for harvest of the latissimus muscle in addition to a separate cutaneous skin island, providing the possibility of a chimeric flap for more complex defects. We provide a detailed description of the surgical technique, a video demonstrating the steps of muscle transposition, a cadaveric vascular injection study, and a clinical case series with postoperative outcomes.

PATIENTS AND OPERATIVE TECHNIQUE

Between September 2021 and July 2022, the latissimus dorsi muscle flap based on the lateral branch of the

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intercostal artery (6th, 7th, and 8th intercostal levels) was utilized for intrathoracic reconstruction in three patients who had undergone prior nonmuscle-sparing thoracotomies with the division of the latissimus dorsi and serratus anterior muscles. Data related to patients' demographics, etiology, and outcomes were collected after institutional review board approval. Details of the treatment course and clinical outcomes are summarized in Table 1. Patients underwent the operation at a mean age of 54 (range 45–65) years and had a mean BMI of 26.6 (±5.6) kg/m^2. The American Society of Anesthesiology category was class III in two patients and class IV in one patient. Mean follow-up duration was 11 months (range 6–15 months). All patients had clinical evidence of flap viability. One patient developed a donor site seroma that resolved following percutaneous drainage.

A preoperative CT angiogram of the chest was obtained in all patients to help delineate the intercostal vascular anatomy and allow for identification of cutaneous and musculocutaneous perforators and their respective intercostal space/level (Fig. 1). A decision is made in conjunction with the thoracic surgeon as to what kind of flap is needed: a muscle-only flap or a chimeric flap (muscle in addition to a separate pedicled fasciocutaneous component).

If a muscle-only flap is needed, the prior thoracotomy incision is utilized for muscle harvest. The distal part of the latissimus dorsi muscle is elevated off the chest wall making sure to preserve all the lateral intercostal muscular branches. A single lateral intercostal vessel is then selected (depending on the size of the perforators and the location of the intrathoracic defect) and the remaining vessels are divided. The lateral intercostal branch is then traced back to its respective intercostal vessel/space.

Takeaways

Question: Does prior thoracotomy dividing the latissimus dorsi muscle and thoracodorsal vessels preclude the use of the latissimus dorsi muscle for intrathoracic reconstruction?

Findings: Via a clinical and a cadaveric study, we demonstrate the utility of chimerism of a latissimus dorsi muscle flap based on perforators from the intercostal artery for intrathoracic reconstruction.

Meaning: The intercostal artery-based latissimus dorsi flap (in isolation or chimerism) is a viable option for intrathoracic reconstruction in patients who had prior thoracotomy and division of the latissimus dorsi muscle and thoracodorsal pedicle.

Subperiosteal dissection is performed to release the vessels from the intercostal groove until free mobility and reach to the defect site are achieved. We routinely include the intercostal muscle with the vessel to protect the pedicle and add bulk that may be necessary for dead space obliteration. When additional bulk is not needed, both the intercostal muscle and nerve can be spared. The flap can be based anteriorly (off the anterior intercostal vessels) or posteriorly (off the posterior intercostal vessels) depending on the location of the intrathoracic defect. Additional pedicle length can be achieved by extending the dissection to the origin of the intercostal vessels. The thoracic surgeon then proceeds with opening the pleural space to complete the intrathoracic portion of the procedure.

Table 1. Summary of Patients and Clinical Outcomes

Patient Number	Patient Age	Primary Surgery	Adjuvant Radiation Therapy	Intrathoracic Pathology	Flap Components	Intercostal Space	How Flap Was Used	Complications	Follow-up Length, Mo	Reoperation	Patient Status
1	53	Ivor-Lewis esophagectomy	Yes	Bronchopleural fistula	Latissimus dorsi muscle and an intercostal artery perforator-based fasciocutaneous flap	7th	Buttress the bronchopleural fistula repair-site (muscle) and obliteration of empty space (skin paddle)	None	15	No	Alive
2	65	Aortic replacement	No	Aortoesophageal fistula	Latissimus dorsi muscle	6th	Cardiac/aortic root vascular graft coverage following aortic replacement with an allograft	None	12	No	Alive
3	45	Paraesophageal hernia repair with mesh repair of the diaphragm	No	Bronchoesophageal fistula	Latissimus dorsi muscle	8th	Buttress esophageal repair	Flap site Seroma 6	6	No	Alive

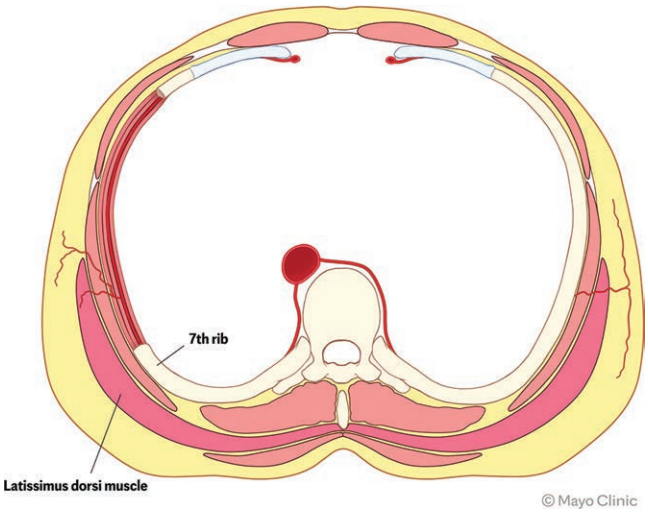

Fig. 1. A schematic showing the intercostal artery anatomy and the configuration and branching pattern of the musculocutaneous branch and cutaneous perforator.

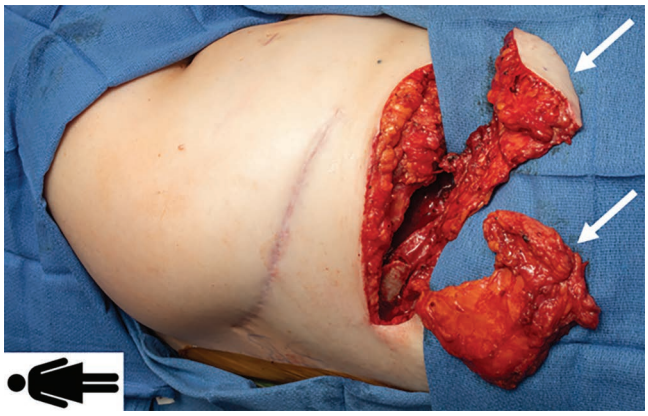

Fig. 2. An Intraoperative photo showing a chimeric flap design, the removed portion of the rib, and the prior thoracotomy scar.

If a chimeric flap is needed (Figs. 2 and 3), a hand-held Doppler is used to locate the cutaneous perforator and a skin paddle is designed accordingly. A wide skin bridge is maintained between the skin paddle and any existing thoracotomy scars to avoid vascular compromise of the intervening skin. The skin paddle is incised first, and the perforator is identified. Through the same incision, the distal part of the latissimus dorsi muscle is elevated off the chest wall to identify the intercostal muscular branches (lateral branches of the intercostal vessels). Ideally, the cutaneous perforator and one of the lateral intercostal branches are traced to the same intercostal space, and therefore, the same intercostal vessel. Following that, the remainder of the flap harvest follows the same steps described above. (**See Video [online],** which shows the chimeric flap transposition.)

Once the intrathoracic portion of the procedure is completed, a 5- to 7-cm segment of the rib is removed to allow for intrathoracic transposition of the flap and prevents pedicle compression. Flap inset then takes place in

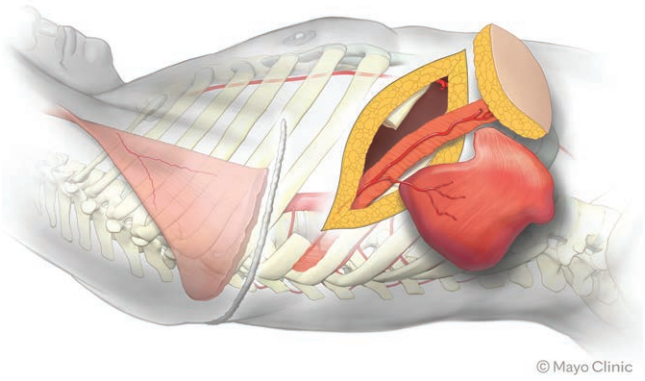

Fig. 3. A schematic showing a chimeric flap design, the removed portion of the rib, and the prior thoracotomy scar.

conjunction with the thoracic surgeon. A chest tube and subcutaneous drain are routinely placed.

For anatomical study, a total of six latissimus dorsi muscles in three cadavers were dissected. The thoracodorsal vessel and all lumbar and intercostal perforators (except the largest one) were ligated. A contrast (Iohexol) was injected into an intercostal perforator and a fluoroscopy image was obtained. There was evidence of vascular pattern delineation along the entire muscle, indicating the adequacy of a single intercostal perforator in perfusing a large segment (or the entirety) of the latissimus dorsi muscle. At least one intercostal perforator was present in all specimens with the majority of perforators present at the 6th, 7th, 8th, and 9th intercostal levels. (**See figures, Supplemental Digital Contents 1 and 2,** which show photographs of the delineation of the vascular pattern following contact injection into an intercostal artery muscular branch following ligation of the thoracodorsal vessels and all other minor pedicles, **http://links.lww.com/PRSGO/C615**, **http://links.lww.com/PRSGO/C616**.)

DISCUSSION

Secondary vascular pedicles to the latissimus dorsi muscle are present as two rows on the deep aspect of the muscle and perfuse the distal part. The medial row of vessels are branches of the lumbar arteries and the lateral row are branches of the intercostal arteries; the distal branches are consistently larger than the more cephalad branches.[1] Around 5–7 musculocutaneous perforators are present at intervals of 1–3 cm; these are approximately 0.8 mm in diameter.[6,7] In addition to musculocutaneous perforators, a large lateral cutaneous perforator, from the lowest intercostal vessels, arises in the distal part of the costal groove, coursing obliquely deep to the intercostal muscles and anterior to the latissimus dorsi and emerging subcutaneously.[8] This cutaneous branch allows for harvest of an intercostal artery perforator-based, fasciocutaneous flap that can be used separately or in chimerism. These anatomic principles form the basis of our described technique. For superior intrathoracic pathology, the superior half of the latissimus muscle can be used for intrathoracic

reconstruction as long as intercostal perforators to that segment of the muscle are present.

In patients with a prior nonmuscle sparing thoracotomy, neither the latissimus dorsi nor the serratus anterior muscles are suitable for intrathoracic transposition. It is for this reason that most thoracic surgeons make concerted effort to perform a muscle-sparing approach.[9,10] Being able to harvest the muscle based on one of the musculocutaneous branches of the intercostal vessels gives the surgeon the ability to still use the previously divided muscle for intrathoracic reconstruction when other alternative flaps may not be available or suitable. The consistent anatomy of lateral intercostal cutaneous perforator provides the surgeon with the flexibility of entertaining the option of flap chimerism when needed. Although a latissimus dorsi musculocutaneous flap can be harvested using this technique, we feel that flap chimerism has an added benefit of providing two separate flaps that can be used for more than one purpose such as repairing a fistula site and obliterating an empty space. In addition, the vascular anatomy of the intercostal vessel gives the surgeon the liberty of basing the flap anteriorly or posteriorly based on the location of the intrathoracic pathology, an anatomic choice that further increases the versatility of this flap. Finally, the flap utilizes muscle that is essentially nonfunctional and denervated, minimizing existing donor site morbidity.

CONCLUSION

A distally based latissimus dorsi muscle flap can be used for intrathoracic reconstruction in patients with prior nonmuscle-sparing thoracotomy when based off an intercostal vascular pedicle.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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