

# Extended Tracheal Resections

Erich Hecker\*, Jan Volmerig

## KEYWORDS

• Tracheal resection • Tracheal reconstruction • Extended tracheal resection • Tracheal release

## KEY POINTS

- Extended tracheal resection is not only an expression of resected length, but rather a combination of patient parameters (eg, gender, size, habitus, comorbidities), the type of approach (cervical vs sternotomy vs cervical plus [split-]sternotomy, thoracotomy), underlying disease, combination of release maneuvers, and the actual length of necessary tracheal resection.
- The maximum possible length of a tracheal resection can be achieved by using laryngeal release, mobilization of the pretracheal plane, bilateral hilar, and complete pericardial incision.
- Depending on the intraoperative findings, all maneuvers can be performed stepwise so as to achieve a tension-free anastomosis.
- The feasibility of particular steps as minimally invasive, video-assisted measures is yet to be established.
- Although primary short-segment resections (ie,  $\leq 2$  cm) generally have good outcomes, the rate of complications in longer resections increases significantly, even in very experienced hands and with release maneuvers.
- Referral to a major center for reoperation after a failed initial attempt is fraught with a high rate of complications and the judgment of an experienced surgeon, both preoperatively and intraoperatively, considering the quality and tension of the tissues is likely to be tremendously important.
- Centers with less volume are urged to consider these facts carefully before undertaking the sporadic case of a potentially longer resection.

## EXTENDED TRACHEAL RESECTIONS

The history of tracheal surgery, beginning with the reports of Aretaeus and Galen on tracheostomy in the second and third centuries, is long and slow paced; it was not until the 1950s and following decades that development finally started to accelerate.<sup>1-4</sup>

The reasons for the delayed development were varied. On the one hand, there are a variety of indications for resections:

In non-neoplastic diseases there are post-therapeutic stenosis, postintubation/posttraumatic lesions, idiopathic stenosis, destruction by extra-tracheal mass, relapsing polychondritis, Wegner

granulomatosis, sarcoidosis, amyloidosis, and tracheopathia osteoplastica.

Neoplastic diseases can be distinguished in rare primary tracheal tumors (malignant or benign) and secondary malignant tracheal tumors.

Squamous cell carcinoma and adenoid cystic carcinoma account for two-thirds of primary tracheal tumors, followed by adenocarcinomas, and mucoepidermoid and other mesenchymal carcinomas. Benign tumors are composed of granular cell tumors, fibrous histiocytoma, chondroma, fibroma, hemangioma, and papilloma.

Secondary malignant tumors arise locally from laryngeal structures, thyroid gland, esophagus, lung/bronchi, or as metastatic disease.

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Department of Thoracic Surgery, Thoraxzentrum Ruhrgebiet, Academic Hospital University Duisburg-Essen, Hordeler Strasse 7-9, Herne 44651, Germany

\* Corresponding author.

E-mail address: [e.hecker@evk-herne.de](mailto:e.hecker@evk-herne.de)

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The various entities with their varying anatomic locations lead to diverse oncological considerations and tactical strategies, as well as surgical approaches.

Today, in the absence of distant metastasis and if local resectability is provided, primary resection is considered the treatment of choice. If resectability is unclear, operative exploration is to be considered. Primary resection is considered successful in the case of microscopic tumor-bearing resection margins in adenoid cystic carcinomas if local control is supported by postoperative radiation. In addition, in cases of benign neoplasm, endoscopic resection is generally considered the method of choice, for instance laser resection.

The unique features of the trachea with regard to its anatomic location, length, structural rigidity, and blood supply need to be considered by the treating physician.

In 1964, Grillo identified the average length of an adult human trachea to be 11,8 cm, ranging from 10 to 13 cm, and containing 18 to 22 cartilaginous rings, approximately 2 rings per centimeter.<sup>5</sup>

The segmental blood supply of the trachea, first determined by Miura and Grillo in 1966 and later confirmed in detail by Salassa and colleagues, is subject to anatomic descriptions.<sup>6,7</sup>

The first successful bronchial anastomosis was described by Jackson and colleagues in 1949 after accidentally severing a main bronchus.<sup>8</sup> In the same year, based on results from trials in 6 fresh human cadavers, Rob and Bateman estimated the feasible resectability of the trachea to be about 2 cm.<sup>9</sup>

This estimate was strongly advocated by Barclay and colleagues in 1950 and was considered valid for several years.<sup>10</sup>

As a result, there has been considerable effort in developing new materials for tracheal prosthetic replacement, including solid tubes of different materials and rigidity, various mesh-type materials in combination with varying support techniques, as well as wire-reinforced dermal grafts and fascia.

To this day, despite all efforts, no consistent means of tracheal replacement or bridging allowing extended resections has been established.

In 1957, Barclay and colleagues<sup>10</sup> reported of a resection of the carina and proximal right main bronchus, leading to a defect length of 5 cm, which was closed using a new technique of mobilization and bronchial anastomosis with the use of grafts.

In this case, the trachea was fully mobilized within the thorax and the left main bronchus severed from the trachea. After resection of the tumor-bearing area, the right lung was elevated after mobilization by division of the pulmonary ligament. The right main bronchus was anastomosed to the trachea. Reconstruction was completed by insertion of the left main bronchus into the incised intermediate bronchus.

Before this operation, Barclay<sup>10</sup> found that mobilization of the lower trachea, including separation of the left bronchus, facilitated trachea resection to an extent of 6 cm on fresh human cadavers.

In the following decades, research included solutions of primary reconstruction/anastomosis

**Table 1**  
Surgical approaches to tracheal resection

Study	n	Cervical, %	Sternal, %	Thoracic, %
Wright et al, <sup>12</sup> 2004	901	74	20	5
Krajc et al, <sup>13</sup> 2009	164	76	21	—
D'Andrilli et al, <sup>14</sup> 2008	35	100	—	1 minithoracotomy for hilar release
Regnard et al, <sup>15</sup> 1996 multicenter only tumors	208	29	Split 11 Full 36	20
Donahue et al, <sup>16</sup> 1997 Re-resections	75	70	Split 24	3
Rea et al, <sup>31</sup> 2001	65	92	Split 6 Full 2	—
Mutrie et al, <sup>17</sup> 2011	105	93	7	Excluded
Cordos et al, <sup>45</sup> 2008	60	88	Split 5	6
Müller et al, <sup>18-22</sup> 1991	40	55	34	10
Abbasidezfouli et al, <sup>23</sup> 2009	494	—	—	"Few cases"

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