*Thorax* (1968), **23**, 307.

# Surgery of tumours in the thoracic portion of the trachea

MIKHAIL PERELMAN AND NATALIA KOROLYOVA

*From the Institute of Clinical and Experimental Surgery, U.S.S.R. Ministry of Public Health, Moscow*

We have operated on nine patients suffering from benign or malignant tumours in the thoracic portion of the trachea. The main clinical symptom was difficulty in breathing, accompanied in the majority of cases by attacks of asphyxia, cough with mucous phlegm, and haemoptysis. The following operations were performed: circular resection of the trachea with end-to-end anastomosis, thoracic tracheotomy with enucleation of the tumour, fenestral resection with auto-alloplasty of the ensuing defect, piecemeal removal of the tumour through the lumen of the trachea, and intrathoracic tracheotomy with biopsy of the tumour. All patients were discharged after the operation. When giving an anaesthetic during an operation on the thoracic portion of the trachea it is expedient to introduce a tube into the left main bronchus from the right pleural cavity and to exclude the right lung from ventilation. These measures ensure convenience of manipulation of the trachea, unhampered by the presence of a tube. End-to-end anastomosis is the best way to restore the thoracic portion of the trachea after circular resection. The problem of replacing large fenestral defects of the trachea can be solved by auto-alloplasty with thick Marlex, preliminarily overgrown with connective tissue.

Primary tumours of the thoracic portion of the trachea are met with more frequently than is supposed. For instance, in 1955 Leonardelli and Pizzetti collected in the world literature 714 such tumours, of which 316 were benign and 398 malignant.

Included among epitheliomas of the trachea are papillomas, frequently accompanied by papillomas of the larynx. Adenomas develop from the mucous glands and include carcinoids, cylindromas, and mucous-epidermoid tumours (Gordyshevsky, 1952; Wilkins, Darling, Soutter, and Sniffen, 1963). More rarely, we find fibromas, chondromas, and some other neoplasms.

The most frequent types of primary malignant tumours are adenocarcinomas (47%) and squamous-cell carcinomas (41%) and, less frequently, sarcomas (12%) (Moiraghi and Garetto, 1964). Metastases of these tumours occur in the lymph nodes of the thorax and later in the lungs, pleura, and liver.

Before the development of modern anaesthesiology and thoracic surgery, operation for a tumour in the thoracic portion of the trachea was considered to be impossible. Only in rare cases were attempts made to remove it in pieces with a bronchoscope.

At present, tumours of the trachea are treated by radiation therapy and surgical methods. The latter include removal of the tumour using a bronchoscope, tracheotomy with enucleation, cutting up or scraping out the tumour followed by diathermo-coagulation of its base and fenestral and circular resection of the trachea. After radiation therapy or other methods of palliative removal of the tumour, a relapse usually occurs.

A radical operation for a tracheal tumour consists in the removal of the neoplasm with a part of the trachea. Access is generally obtained through the pleural cavity, but longitudinal sternotomy is occasionally used.

When operating on the thoracic portion of the trachea we have had considerable difficulty in ensuring adequate ventilation of the lungs during the time that the tracheal lumen is open. Owing to the numerous inconveniences of operating with intubation of the trachea (Nissen, 1961; Woods, Neptune, and Palatchi, 1961), Adkins and Izawa (1964) performed resection of the thoracic portion of the trachea using artificial circulation of the blood, *i.e.*, without the need to ventilate the lungs.

The most difficult part of tracheal surgery is to close large fenestral or circular defects in the tracheal wall. In clinical practice it is usually

impossible to close large fenestral defects of the thoracic portion of the trachea, left after removal of the tumour, by means of a longitudinal or circumferential suture without greatly constricting the lumen.

We know of only one such successful operation on a distended trachea from which a tumour was removed; the histological structure of the tumour was not mentioned by the authors (Karpinishan, Bogdan, and Trayan, 1966). To close big fenestral defects we have used muscle-periosteal grafts, wire-stiffened skin or fascial grafts, and polyethylene plastic.

In 1964 Adkins and Izawa, and in 1965 Yeh, Batayias, Peters, and Ellison, on the basis of experimental data, reported a successful fenestral resection of the thoracic portion of the trachea, using a patch of Marlex polyethylene net to remedy the defect. In the first case the operation was performed for a cylindroma, and in the second for a metastasis of an intestinal adenocarcinoma. The graft was hermetically sealed by wrapping it in the mediastinal pleura or in a loose strip of the pericardium.

Restoration of the thoracic portion of the trachea after circular resection is achieved chiefly by end-to-end anastomosis. Such operations were successfully performed by Macmanus and McCormick (1954), Nicks (1956), Šálek, Tichý, and Luttenberg (1959), Houel and Callige (1960), Archer, Harrison, and Moulder (1963), Cantrell and Guild (1964), Sato, Nakagawa, Izumi, and Nagasawa (1964), Mathey, Lemoine, Langlois, Labrosse, Bical, and Zuber (1965), Roy and Vandooren (1965), and Avilova (1966). It is considered, however, that after removal of a portion of the trachea more than 4 cm. in length it is likely to be impossible to perform an anastomosis, and the defect has to be bridged by a graft. Methods of alloplasty for large circular defects of the trachea are being developed experimentally and in our clinic. The best experimental results have been obtained by means of Teflon grafts (Ekeström, 1958; Atamanyuk and Melrose, 1966), Marlex (Beall, Harrington, Greenberg, Morris, and Usher, 1962, 1963a, b; Korolyova, 1964), and apron net (Furmanov, 1964).

Alloplasty of circular defects of the trachea was begun in our clinic in 1948 (Longmire, 1948). These methods are being further developed (Ellis, Harrington, Beall, and DeBakey, 1962; Rivkin and Meyers, 1963; Kramish and Morfit, 1963; Perelman, Kuzmichev, and Korolyova, 1965).

We have had under our observation 29 patients with different lesions of the trachea that required surgical treatment. Eleven patients (five men and six women) suffered from tumours of the thoracic portion. Their ages ranged from 30 to 65 years. The time that elapsed from the first clinical symptoms of the disease to the establishment of the correct diagnosis varied from three months to six years. After tumours of the trachea had been diagnosed, in five cases attempts were made to remove the growth with the bronchoscope, but in all a relapse occurred during the first year.

The chief clinical symptoms of these tumours in the thoracic portion of the trachea are listed in Table I. All patients complained of difficulty in breathing, and in the majority there were attacks of respiratory obstruction. On account of this obstruction eight patients were treated for a long time without result for erroneously diagnosed bronchial asthma. All were troubled by a cough with mucous phlegm. Haemoptysis was observed in six patients. Moreover one of them (with a relapse of cylindroma in the thoracic portion) suffered from profuse haemorrhage from the tumour into the lungs. Five patients complained of pain in the chest. In eight, dry crepitation was heard in the lungs from time to time. A diminution in the efficacy of quiet respiration was commonly found. A patient suffering from a squamous-cell cancer of the trachea lost 15 kg. in weight in three months.

TABLE I

CLINICAL SYMPTOMS OF PATIENTS WITH TUMOURS IN THE THORACIC PORTION OF THE TRACHEA

| Sex and Age | Impaired Respiration | Cough with Mucous Phlegm | Attacks of Asphyxia | Dry Crepitation in Lungs | Haemoptysis | Pain in Chest | Loss of Weight |
|---|---|---|---|---|---|---|---|
| M. 50 | + | + | − | + | + | + | − |
| F. 43 | + | + | + | − | + | − | − |
| F. 30 | + | + | + | − | − | − | − |
| F. 30 | + | + | + | − | + | − | − |
| F. 33 | − | + | + | + | + | − | − |
| F. 37 | + | + | + | + | + | − | − |
| M. 50 | + | + | + | + | + | + | + |
| M. 38 | + | + | − | + | + | + | + |
| F. 47 | + | + | + | + | − | + | + |
| M. 40 | + | + | + | + | + | + | − |
| M. 65 | + | + | + | + | + | − | − |

For diagnostic purposes frontal and lateral tomography of the trachea, tomography with frontal enlargement, and, when necessary, contrasting examination of the trachea were used. Tracheoscopy proved to be a particularly valuable method of diagnosis, as it permitted examination of the internal surface of the trachea; and histological tests were possible.

Benign tumours were found in seven cases, malignant in four. Five patients suffered from adenomas (three cylindromas, one carcinoid, one mucous-epidermoid tumour). There was one case of adenolipoma of the trachea, one polyp, one haemangioendothelioma, two squamous-cell cancers with cell nests, and one squamous-cell cancer without.

Of 11 patients with tumours of the trachea, nine were operated upon. As the means of access we chose lateral thoracotomy in the fourth intercostal space on the right-hand side. Medial sternotomy, applied in one case by Avilova (1966), was found to be less convenient, in our opinion, and should not be used for these operations.

## METHODS

We have developed the following surgical methods.

The pleural cavity is opened under an endotracheal anaesthetic using controlled breathing. An ordinary intratracheal tube is then inserted slightly below the vocal chords. The anaesthetics chiefly used are phthorotan, fluoran, pure chloroform or chloroform in a mixture with nitrous oxide.

When the pleural cavity has been laid open the condition of the trachea is ascertained by palpation. In cases of malignant tumours we make sure that there are no metastases or other lesions that would contraindicate excision. The arch of the azygos vein is ligated and severed. The right-hand vagus nerve is reflected.

In order to avoid the necessity for artificial blood circulation, and to ensure pulmonary ventilation during opening of the trachea, thus creating favourable conditions for the work of the surgeons, in eight cases we used a new method of intubation of the lungs, which in our opinion greatly improves the conditions for operating on the thoracic portion of the trachea. This consists in performing a bronchotomy in the region of the membranous part of the right main bronchus. A stiffened tube is introduced into the opening and passed down beyond the bifurcation of the trachea into the left main bronchus. The further stages of the operation—resection of the affected part of the trachea and its restoration—are carried out with ventilation of the left lung only. On completion of the plastic operation on the trachea the tube is withdrawn from the left main bronchus, the lungs are ventilated by means of an ordinary orotracheal tube, and the opening in the wall of the right main bronchus is sutured. This method ensures respiration and convenience of manipulation of the trachea, unhampered by a tube.

As suturing material we use chromicized catgut No. 0 or Orsilon upon round non-traumatic needles. The wall of the trachea is sutured through all the layers, the knots being tied on the surface.

The different types of operation performed for tumours in the thoracic portion of the trachea are given in Table II.

TABLE II

SURGERY OF TUMOURS IN THE THORACIC PORTION OF THE TRACHEA

| Sex and Age | Diagnosis | Access | Type of Operation | Size of Resection | Size of Tracheal Defect (mm.) | Outcome |
|---|---|---|---|---|---|---|
| F. 30 | Mucous-epidermoid tumour | Lateral thoracotomy from 4th intercostal space on right | Circular resection of trachea with intertracheal anastomosis | 4 rings (26 mm.) | 48 | Discharged |
| M. 38 | Squamous-cell cancer with cornification | Posterior thoracotomy from 4th intercostal space on right | Circular resection of trachea with intertracheal anastomosis | 5 rings (38 mm.) | 60 | Discharged |
| F. 43 | Cylindroma (relapse) | Lateral thoracotomy from 4th intercostal space on right | Circular resection of trachea with intertracheal anastomosis | 4 rings (28 mm.) | 53 | Discharged |
| F. 30 | Cylindroma | Lateral thoracotomy from 4th intercostal space on right | Circular resection of trachea with intertracheal anastomosis | 5 rings (29 mm.) | 41 | Discharged |
| M. 40 | Carcinoid | Lateral thoracotomy from 4th intercostal space on right | Circular resection of trachea with intertracheal anastomosis | 4 rings (46 mm.) | 60 | Discharged |
| F. 37 | Haemangio-endothelioma (relapse) | Lateral thoracotomy from 4th intercostal space on right | Fenestral resection of trachea; defect closed by Marlex graft overgrown with connective tissue | 26 × 16 mm. | 30 × 18 | Discharged |
| M. 65 | Adenolipoma | Lateral thoracotomy from 4th intercostal space on right | Incision of membranous part of trachea; removal of tumour, 2 × 2·5 cm. | | | Discharged |
| M. 50 | Cylindroma (relapse) | Median incision in neck; lateral thoracotomy from 4th intercostal space on right | Tumour cut into pieces through lumen; removal of foreign body | | | Relapse |
| F. 47 | Squamous-cell cancer without cornification | Posterior thoracotomy from 4th intercostal space on right | Intrathoracic tracheotomy; biopsy | | | Discharged |

In five of the nine patients operated upon, circular resection of the trachea with end-to-end anastomosis was performed. In one case, the membranous part of the trachea was incised and an adenolipoma, 2×2·5 cm. in size, was enucleated from under the mucous membrane. In another, fenestral resection was performed with autoalloplasty of the ensuing defect. On one patient we performed a palliative operation, the tumour being removed piecemeal through the lumen of the trachea; in another, intrathoracic tracheotomy with biopsy of the tumour was done.

All seven patients who underwent a radical operation for tumours in the thoracic portion of the trachea were discharged from hospital in satisfactory condition. In the patient who had the cylindroma removed through the lumen of the trachea, a relapse occurred after one month. The condition of the patient who underwent a palliative operation did not change.

## REFERENCES


Archer, F. L., Harrison, R. W., and Moulder, P. V. (1963). Granular cell myoblastoma of the trachea and carina treated by resection and reconstruction. *J. thorac. cardiovasc. Surg.*, **45**, 539.

Adkins, P. C., and Izawa, E. M. (1964). Resection of tracheal cylindroma using cardiopulmonary bypass. *Arch. Surg.*, **88**, 405.

Atamanyuk, M. Y., and Melrose, D. G. (1966). Plastic prostheses for reconstruction of the trachea. *Khirurgiya (Mosk.)*, **42**, no. 1, p. 58.

Avilova, O. M. (1966). Adenoma of the thoracic region of the trachea treated by circular resection of the trachea with direct anastomosis. (In Russian.) *Grud. Khir.*, **8**, no. 2, p. 125.

Beall, A. C., Harrington, O. B., Greenberg, S. D., Morris, G. C., and Usher, F. C. (1962). Tracheal replacement with heavy Marlex mesh. Circumferential replacement of the cervical trachea. *Arch. Surg.*, **84**, 390.

—— —— —— —— —— (1963a). Tracheal reconstruction with heavy Marlex mesh. *Ibid.*, **86**, 970.

—— —— —— Usher, F. C., and Morris, G. C. (1963b). Circumferential replacement of thoracic trachea with Marlex mesh. *J. Amer. med. Ass.*, **183**, 1082.

Cantrell, J. R., and Guild, H. G. (1964). Congenital stenosis of the trachea. *Amer. J. Surg.*, **108**, 297.

Ekeström, S. (1958). Reconstruction of the intrathoracic trachea. An experimental study in dogs. Stockholm.

Ellis, P. R., Harrington, O. B., Beall, A. C., and DeBakey, M. E. (1962). The use of heavy Marlex mesh for tracheal reconstruction following resection for malignancy. *J. thorac. cardiovasc. Surg.*, **44**, 520.

Furmanov, Yu. A. (1964). The use of synthetic materials for grafting the trachea and the bronchi (experimental research). Author's summary of his M.S. thesis (Kiev).

Gordyshevsky, T. I. (1952). Concerning cylindromas and adenomas of the trachea and the bronchi.

Houel, J., and Callige, P. (1960). Les possibilités chirurgicales dans les tumeurs primitives de la trachée endothoracique. *Afr. franç. chir.*, **18**, 139.

Karpinishan, K., Bogdan, T., and Trayan (1966). Surgery of primary tumours of the thoraxial section of the trachea. (In Russian.) *Grud. Khir.*, **8**, no. 3, p. 54.

Korolyova, N. S. (1964). Resection and grafting of the trachea in experiment. In *Questions of Reconstructive Surgery: Proceedings of the First Scientific Session of the Research Institute of Clinical and Experimental Surgery and of the Chest Surgery Clinic of the Sechenov Medical Institute*, no. 1, p. 41.

Kramish, D., and Morfit, H. M. (1963). The use of a Teflon prosthesis to bridge complete sleeve defects in the human trachea. *Amer. J. Surg.*, **106**, 704.

Leonardelli, G. B., and Pizzetti, F. (1955). *Le neoplasie primitive della trachea.* Ed. Deca, Milano.

Longmire, W. P. (1948). The repair of large defects of the trachea. *Ann. Otol. (St Louis)*, **57**, 875.

Macmanus, J. E., and McCormick, R. (1954). Resection and anastomosis of the intrathoracic trachea for primary neoplasms. *Ann. Surg.*, **139**, 350.

Mathey, J., Lemoine, G., Langlois, J., Labrosse, C., Bical, R., and Zuber, C. (1965). Un cas de resection tracheale et un cas resection tracheobronchique. *Mém. Acad. Chir.*, **91**, 621.

Moiraghi, P., and Garetto, G. (1964). Tumori della trachea. *Cancro*, **17**, 30. Abstracted in *Surg. Gynec. Obstet.*, 1965, **121**, 1141.

Nicks, R. (1956). Restoration and reconstruction of the trachea and main bronchi. *J. thorac. Surg.*, **32**, 226.

Nissen, R. (1961). Extrakorporelle Zirkulation für langdauernde (30 minuten) Atemunterbrechung zur Operation bifurkationsnaher Trachealgeschwülste. *Schweiz. med. Wschr.*, **91**, 957.

Perelman, M. I., Kuzmichev, A. P., and Korolyova, N. S. (1965). Resection and grafting of the trachea and the bronchi. Report at the 28th National Congress of Surgeons.

Rivkin, L. M., and Meyers, J. (1963). Trachée thoracique artificielle. *Presse méd.*, **71**, 2180.

Roy, B., and Vandooren, M. (1965). Resection circulaire de la trachée thoracique pour tumeur bénigne. *Mém. Acad. Chir.*, **91**, 639.

Šálek, J., Tichý, S., and Luttenberg, J. (1959). Primäre Resektion der Brusttrachea wegen Karzinoms. *Thoraxchirurgie*, **7**, 343.

Sato, R., Nakagawa, J., Izumi, Y., and Nagasawa, I. (1964). Stricture of thoracic trachea following closed chest injuries. *J. thorac. cardiovasc. Surg.*, **47**, 566.

Wilkins, E. W., Darling, R. C., Soutter, L., and Sniffen, R. C. (1963). A continuing clinical survey of adenomas of the trachea and bronchus in a general hospital. *Ibid.*, **46**, 279.

Woods, F. M., Neptune, W. B., and Palatchi, A. (1961). Resection of the carina and main-stem bronchi with the use of extracorporeal circulation. *New Engl. J. Med.*, **264**, 492.

Yeh, T. J., Batayias, G., Peters, H., and Ellison, R. G. (1965). Metastatic carcinoma to the trachea: report of a case of palliation by resection and Marlex graft. *J. thorac. cardiovasc. Surg.*, **49**, 886.