

Resection of the Carina and Lower Trachea

HERMES C. GRILLO, M.D., HENRIK H. BENDIXEN, M.D., THOMAS GEPHART, M.D.

*From the Harvard Medical School Department of Surgery
at the Massachusetts General Hospital*

RESECTION of the tracheal carina and lower trachea presents special problems in reconstruction and also in physiologic management during operation. The primary requirements for intrathoracic tracheobronchial reconstruction are reconstitution of a semi-rigid, airtight conduit lined with ciliated *respiratory* epithelium. In the special case of the carina a simple scheme of reattachment of main bronchi to trachea is needed if both lungs are to be preserved. Physiologic maintenance of the patient during the procedure should be such that these anatomic goals may be realized without undue hurry at any point in the procedure.

Two cases are reported illustrating tracheal resection performed in accord with these criteria. The first report is of a successful carinal excision. The second case demonstrates the applicability of the technic of transitory physiologic pneumonectomy to surgical management of an immediately supracarinal lesion.

Case Reports

Case 1. The patient was a 48-year-old housewife who had been well until hospitalized elsewhere five years previously for pneumonia. She had her first and only episode of hemoptysis then. Subsequently she had frequent "colds" associated with marked dyspnea. In the five months prior to admission she suffered from nearly constant respiratory distress which increased in severity so that she could not climb one flight of stairs without rest nor sleep recumbent. She had to pause between phrases while speaking. Chest x-rays had been reported to be negative during this time, until November 1962 when close examination revealed a mass in the lower trachea. She was referred to the M.G.H.

She was dyspneic at rest, unable to lie flat and the least effort caused severe respiratory distress. She had an audible expiratory wheeze. Chest

was hyperresonant. Blood pressure was 190/110. Hematocrit was 45 per cent. Arterial oxygen saturation was 96 per cent; carbon dioxide tension 37 mm. Hg; carbon dioxide concentration 30 mEq./L.; arterial pH 7.51. Chest x-rays demonstrated a tumor about 3.0 cm. in diameter within the lower trachea (Fig. 1). Laminograms placed the tumor at or just above the carina, confirmed a posterior origin and suggested an extratracheal as well as intratracheal extent (Fig. 2). Only 2 or 3 mm. of air space remained in the tracheal lumen.

Bronchoscopy was performed under topical anesthesia with great care to avoid trauma and with no attempt at biopsy. A smooth tumor characteristic of bronchial adenoma was seen occluding about 80 per cent of the tracheal lumen, which lay anteriorly, the tumor appearing to originate from the posterior wall (Fig. 3b). Following bronchoscopy, she rapidly developed progressively more severe dyspnea and was unable to maintain adequate ventilation or oxygenation. She was unable, in particular, to expire satisfactorily, manifesting a continuously hyperexpanded thorax. Under these circumstances positive pressure assistance was useless. Emergency thoracotomy (H. C. G.) was done (11.26.62). Premedication was with atropine sulphate 0.3 mg., given intravenously immediately before the start of anesthesia. The patient, exhausted from respiratory distress and able to breathe only in a semi-sitting position, went to sleep following 50 mg. of thiopental sodium and induction of anesthesia was continued with nitrous oxide and oxygen in a 2:1 ratio. Lidocaine 4 per cent was sprayed on the larynx and trachea to facilitate endotracheal intubation with a cuffed Tovell tube No. 7. The tip of this tube was placed in the trachea above the level of the tumor. Maintenance of anesthesia was with halothane, 0.8 to 1.5 per cent in oxygen. Ventilation was assisted at all times. Muscle relaxants were not used at any time (H. H. B.). After reflecting the breast upwards, the right hemithorax was opened through an anterior third intercostal space incision which was carried from the border of the latissimus dorsi muscle laterally to the sternum anteriorly, joining with a median sternotomy (Fig. 3a). The lungs were markedly hyperexpanded and firm. Division of the azygous

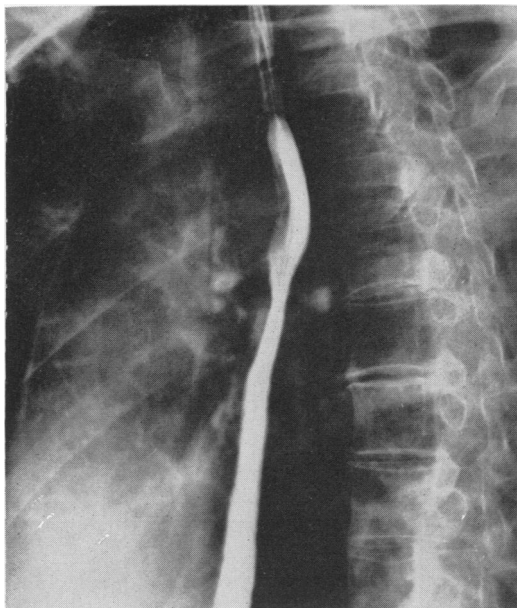


FIG. 1 (Case 1). Oblique roentgenogram showing tumor in lower trachea.



FIG. 2 (Case 1). Laminogram showing tumor at carinal level.

vein and anterior retraction of the superior vena cava permitted free access to the trachea. The trachea was mobilized throughout its intrathoracic extent, the right and left main bronchi freed

well out and the right pulmonary artery dissected free. The left pleura was not opened. The trachea was initially opened transversely above the tumor to assess its extent. It was found to arise from the lower 2 cm. of the posterior wall of trachea and also from the horizontal portion of carina itself as well as the first centimeter of right and left main bronchi (Fig. 3b). Lobulations of tumor extended into both main bronchi above and below the levels of origin.

The left main bronchus was divided, removing a "V" of posterior wall to insure adequate margin beyond tumor. The left main bronchus was intubated with a No. 9 Tovell tube (cuff inflated) connected with a sterile Y-piece and corrugated tubing to the anesthesia machine directly from the open chest (Fig. 3c), thus eliminating the potential problems of increased dead space and airway resistance. A variety of endotracheal tubes of differing types and sizes were sterile and immediately available. Ventilation was now carried out entirely with the left lung. In order to main-

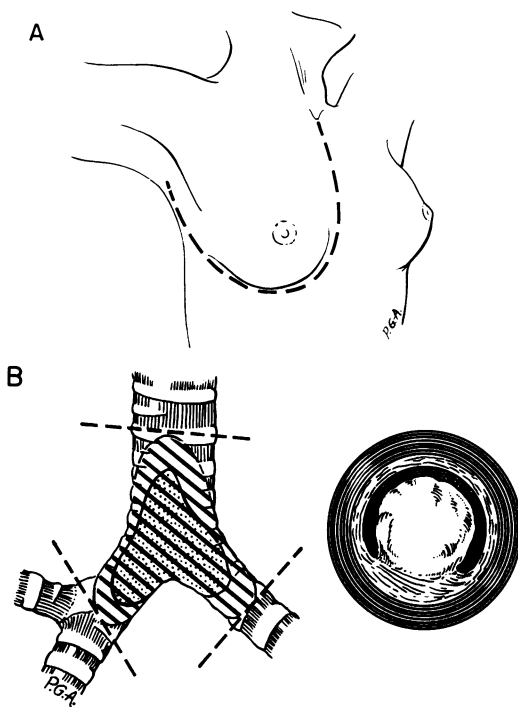
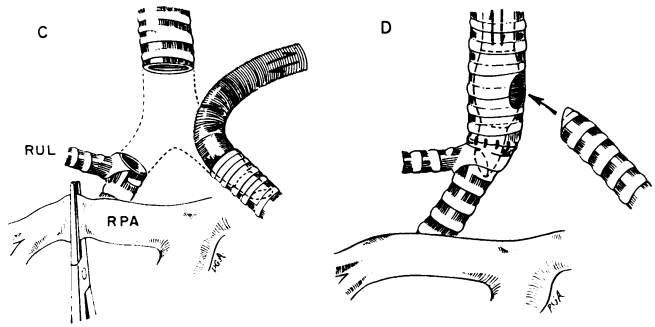


FIG. 3 (Case 1). A. The incision. The breast was reflected upward with the pectoral muscles and the thorax entered through the third intercostal space connecting with median sternotomy. B. The extent of the tumor is diagrammed. The stippled area outlines the area of tumor attachment on posterior tracheobronchial wall; it also arose from the carina itself. Lines of resection are dotted. Bronchoscopic view is sketched at the right. The artist has been generous in depicting the lumen remaining.

FIG. 3C. Tumor has been resected, leaving a 4 cm. gap. Left main bronchus has been intubated through operative field. Right pulmonary artery has been clamped so that right lung is no longer ventilated or perfused. D. After anastomosis of right main bronchus to trachea, endotracheal tube has been advanced to ventilate perfused right lung. Anastomotic site on side wall of trachea has been prepared. Left lung is permitted to ventilate directly during this period, pleura being intact on that side.



tain the best possible tissue oxygenation the right pulmonary artery was clamped, so that the unventilated lung was not perfused. The trachea was transected above the tumor and the right main bronchus just above the origin of the right upper lobe bronchus, removing a total length of 4 cm. between resection margins. After further mobilization of the structures of the right hilus, the trachea and right main bronchus were anastomosed end-to-end using 4-0 Mersilene sutures in single layer. A long endotracheal tube was then advanced through the anastomosis into the right main bronchus, so that its balloon was just proximal to the suture line. Ventilation and perfusion of the right lung were now resumed. An ovoid opening was made in the lower tracheal segment and the left main bronchus sutured to it (Fig. 3d) after closing the apex of the "V." During the brief period required for completion of this suture line, the patient was permitted to ventilate her left lung directly into the thoracic cavity. The endotracheal tube was next pulled back above the second suture line achieving good ventilation of both lungs (Fig. 3c). Second layer support was accomplished with local flaps of pleura, connective tissue and lymph nodes.

Postoperatively the patient did well. She was able to raise secretions well and did not require tracheostomy. She was vastly relieved subjectively and objectively immediately after recovery from anesthesia. The tumor was a cylindroma. Bronchoscopy done on re-admission for study on 12. 21.62 showed good healing with a small tab of granulation tissue at the new left main bronchial orifice anteriorly. A bronchogram (1.24.63) confined to the main bronchial distribution showed some narrowing of the left main bronchial take off, where the bronchial lumen had been narrowed by suture to attain maximal length. The lungs were well aerated (Fig. 4a, b). The patient continued to do well.

Although operation was required as an emergency the technical procedure was

unhurried. At all times the patient was under full physiologic control with stable ventilation and pulmonary perfusion. Extensive mobilization of the intrathoracic trachea and hila of the lungs permitted wide resection of the carinal region, obtaining adequate margins above and below tumor but allowing primary local reconstruction by direct anastomosis.

Case 2. The patient was a 64-year-old housewife who had noted increasingly labored breathing for six months. She believed that her voice had changed. She had one episode of hemoptysis; bronchoscopy demonstrated a tracheal tumor. She was referred to the M.G.H. Physical examination of her chest was negative. X-ray showed a lobu-

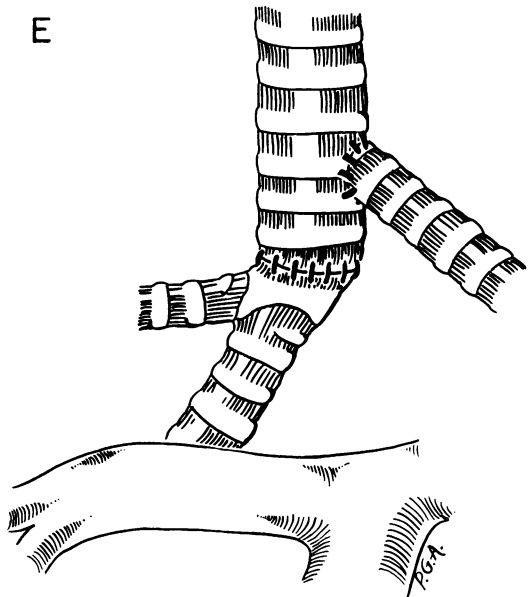


FIG. 3E. The completed anastomosis.

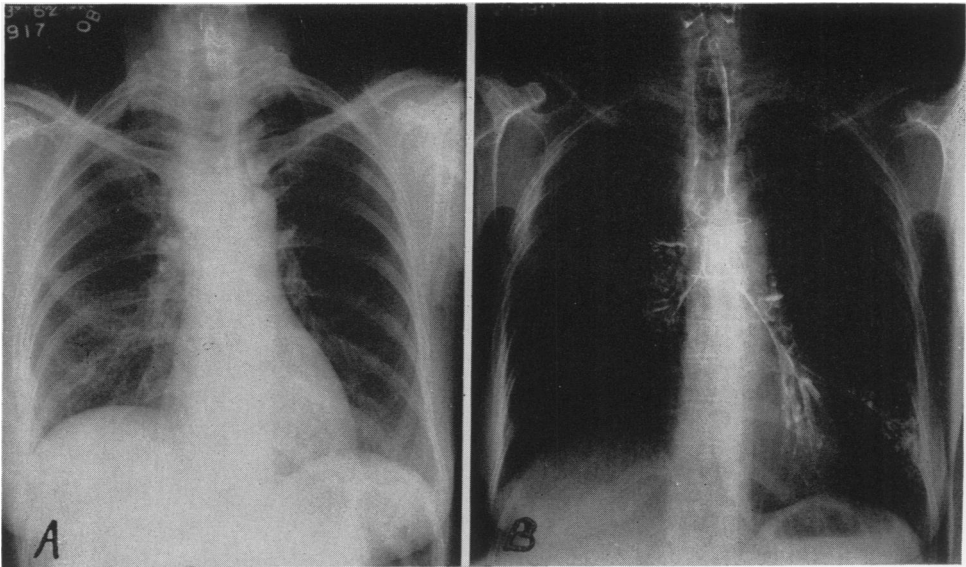


FIG. 4 (Case 1). A. Postoperative roentgenogram. B. Postoperative tracheobronchogram.

lated density overlying the lower trachea. Antero-posterior and lateral laminograms demonstrated a broad based lesion measuring $2.3 \times 1.8 \times 1.8$ cm. attached to the left posterolateral tracheal wall (Fig. 5).

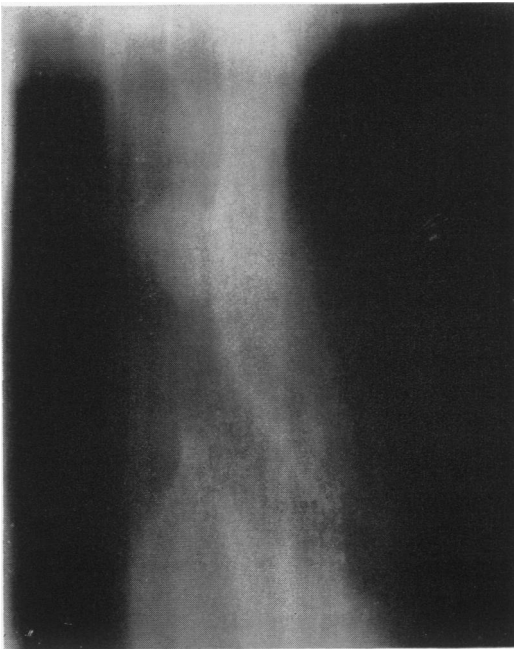


FIG. 5 (Case 2). Laminogram showing tumor above the carina. Lateral tomogram showed the tumor to be of greater antero-posterior extent.

Anesthesia was induced by the same technic as in Case 1 (H. H. B.). Bronchoscopy by Dr. Edward B. Benedict showed a large, irregularly surfaced tumor which bled easily. Only a 3.0 mm. airway appeared to be open. Exploration was done (T. G. and H. C. G.) in the same manner as described in Case 1. The tumor was resected by removing a *sleeve* of trachea, initially including three tracheal rings. The trachea was opened transversely below the tumor. This section was close enough to carina that intubation of the left main bronchus provided a mechanically favorable system for easy completion of the posterior portion of the tracheal anastomosis. For physiological stability the right pulmonary artery was clamped during the part of the procedure performed while the right lung was not ventilated. The anterior portion was completed with the endotracheal tube advanced into the right main bronchus.

The lesion was a squamous cell papilloma. Postoperative course was uneventful. The patient left the hospital on her thirteenth postoperative day and has had no further difficulty.

Location of tumor just above the carina may present difficulties in anesthetic management although the basic surgical problem requires only a sleeve resection. Use of the same technic of transitory physiologic pneumonectomy, ventilating alternately left and then right lungs, made accomplishment of anastomosis easy. Sleeve

resection with end to end anastomosis was by far the most direct and safest method of excision, avoiding the complexities of healing which may occur in patching partial tracheal wall defects with buttressed autogenous tissue.

Discussion

The importance of the drainage function of the trachea, which is accomplished by specialized ciliated epithelium, in addition to the trachea's characteristics of an air duct requiring lateral rigidity, longitudinal flexibility, and air-tightness in the intrathoracic portion have been stressed.³ For these reasons, wherever possible, reconstruction after tracheal resection is best performed using the patient's own tracheobronchial tree, without prosthesis. Direct anastomosis is preferable, where possible, to any patching procedure. Mobilization of the entire intrathoracic trachea and, if required, of the hila of the lungs permits resection of considerable lengths of trachea with primary anastomosis. In the first case a gap of 4 cm. was bridged in this way. Barclay, McSwan, and Welsh² previously reported successful management of carinal tumor by similar mobilization and resection, suturing the left main bronchus to the right bronchus intermedius. An unsuccessful attempt has been reported recently.¹ The problem of tracheal reconstruction after resection of very long lengths of trachea remains to be solved ideally.⁵ Requirements of cervical tracheal repair are less rigorous since initial air-tightness is not essential and, further, constant attention may be given postoperatively to an easily available airway during prolonged reparative processes.⁴

Anesthetic management of patients with carinal and lower tracheal tumors has long presented difficulties. It is essential to successful resection and reconstruction of the trachea that the patient be in continuous physiologic balance and that no phase of

surgery be compromised by undue urgency. Carinal resection might be accomplished with assistance of extra-corporeal perfusion.⁶ However, the directness of the method of anesthesia described permits full control of the patient under optimal conditions without adding the hazards of the pump-oxygenator. The refinement of temporarily eliminating perfusion of an unventilated lung would seem to be physiologically beneficial.

Summary

A successful case of carinal resection for cylindroma and a second case of lower tracheal resection for squamous papilloma illustrate the management of such problems by tracheobronchial mobilization and primary anastomosis. This meets ideal anatomic requirements for tracheal reconstruction. The operative requirement for complete anesthetic control during all phases of tracheal surgery is met by the technic of transitory physiologic pneumonectomy.

References

1. Archer, F. L., R. W. Harrison and P. V. Moulder: Granular Cell Myoblastoma of the Trachea and Carina Treated by Resection and Reconstruction. *J. Thorac. and Cardiovasc. Surg.*, **45**:539, 1963.
2. Barclay, R. S., N. McSwan and T. M. Welsh: Tracheal Reconstruction Without the Use of Grafts. *Thorax*, **12**:177, 1957.
3. Belsey, R.: Resection and Reconstruction of the Intrathoracic Trachea. *Brit. J. Surg.*, **38**:200, 1950.
4. Ellis, P. R., O. B. Harrington, A. C. Beall and M. E. DeBakey: The Use of Heavy Marlex Mesh for Tracheal Reconstruction Following Resection for Malignancy. *J. Thorac. and Cardiovasc. Surg.*, **44**:520, 1962.
5. Michelson, E., R. Solomon, L. Mann and J. Ramirez: Experiments in Tracheal Reconstruction. *J. Thorac. and Cardiovasc. Surg.*, **41**:748, 1961.
6. Woods, F. M., W. B. Neptune and A. Palatchi: Resection of the Carina and Main Stem Bronchi with the Use of Extracorporeal Circulation. *New Engl. J. Med.*, **264**:492, 1961.