Summary

A practical and comprehensive system allowing extensive circumferential tracheal resection and reconstruction at any level is presented. In the *mediastinum* repair is accomplished by the ideal method of end-to-end anastomosis, made possible by wide anatomic mobilization—thus avoiding the hazards of intrathoracic prostheses. In the *neck*, a full-thickness tube of autogenous skin, supported by buried plastic rings, is simply constructed in two stages—affording prompt healing, lack of stenosis and good function despite absence of respiratory epithelium. Laboratory studies and clinical applications are described.

Acknowledgment

The experimental work briefly described was accomplished with the collaboration of Dr. Ellen F. Dignan and Dr. Tsuyoshi Miura. Some of the laboratory studies have been reported and some will be detailed elsewhere. Clinical anesthesia was planned and managed by Dr. Henrik H. Bendixen. Case 2 was operated upon with Dr. Thomas Gephart and Case 3 with Dr. James M. Shannon. The plastic rings were fabricated by Mr. Carl Hewson, Brunswick Manufacturing Co., Inc., and the needles by Mr. Carl Althausen, Massachusetts General Hospital Instrument Shop.

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Discussion

Dr. James R. Cantrell (Seattle): I am certain that all of us are aware of the availability of additional tracheal length following mobilization in the mediastinum. The re-implantation of the bronchus is quite a feasible procedure, and one which will greatly enhance the ability to repair such defects.

However, one must be aware of the fact that to a considerable extent the ability to mobilize the trachea depends upon its inherent elasticity. In younger individuals this elasticity is really quite remarkable but, with increasing age, this elasticity becomes quite strikingly diminished. In a series of cadavers in which we removed the trachea and attempted to determine the length of trachea which

could be resected without producing unacceptable levels of tension on the anastomosis, we found that in individuals over 80 years of age, primary suture could not be accomplished after resection of even a single ring. We estimated that no more than one ring could be resected in the average 60-year-old. I think that this is a matter which must be taken into consideration in resetting the trachea in aged individuals in whom such tumors and other lesions are so apt to occur.

DR. LYMAN A. BREWER (Los Angeles): Dr. Grillo has presented a fascinating paper on tracheal resection and replacement. He is on unimpeachable grounds in mobilizing the patient's own trachea for replacement in the mediastinum. Although this technic is complicated, it has been successful.

We have performed 21 tracheal resections; most of them minor resections involving only a ring or so, but six of them were major resections of the type that he describes. We rely on two important ancillary technics: first, mild hypothermia (down to 32° C), which tides the patient over those periods of hypoxia when the endotracheal tube is disconnected and the prosthesis is being sealed. Secondly, we have used the pedicled pericardial fat graft to reinforce tracheal grafts and reconstruction. This technic was developed primarily for closing the bronchial stump. The mobilized pericardial fat graft (thoracic omentum) is just as effective in sealing over the tracheal anastomosis as is the abdominal omentum for the gastrointestinal tract.

Since we have found fascia lata to be viable in the pleural cavity for pleural partition operations, it has been used for tracheal replacement with stainless steel or Marlex mesh to give noncollapsing support. With your indulgence I would like to mention two cases.

The first is a patient with an extensive squamous cell carcinoma tumor occupying most of the thoracic trachea as outlined on the bronchogram. (Slide)

In resecting the thoracic trachea a small tongue of mucosa was preserved, very much as Dr. Dunphy described this morning. The wire mesh prosthesis covered with fascia lata was anastomosed to the tracheal stump: The pericardial fat graft reinforced the anastomosis. (Slide)

The postoperative film showed the lungs to be expanded with good aeration. (Slide)

This patient died about 3 months later following a coronary occlusion without evidence of cancer at autopsy.

In the postmortem specimen, the artificial trachea presented an excellent airway, lined with viable mucosa. (Slide). The fascia lata graft lived and an adequate mucosa lined airway was present.

Time does not permit presentation of the second case in detail. In this case the entire cervical and thoracic trachea were resected *in toto* with the exception of three or four rings close to the carina. A fascia lata graft reinforced with Marlex mesh graft replaced the resected trachea. Although this provided an excellent airway, the mucosa failed to regenerate so that removal of secretions presented insurmountable problems. The patient eventually developed bronchiectasis and finally died of hemorrhage several months later. This case should be counted as a failure. I believe that it points up the fact that although we can resect and replace the entire esophagus or a major portion of the thoracic aorta, we have no means at present for a total resection of the trachea. This is a challenge for the future.

I do not wish these remarks to detract from Dr. Grillo's splendid presentation. He has developed the most extensive mobilization of the thoracic trachea yet reported. This technic is an important contribution to the surgery of the trachea.

DR. HERMES C. GRILLO (closing): Dr. Cantrell's experiments and measurements of tension in the experimental laboratory were of great help to us and served as guidelines, even though they had to be transferred with caution to the human situation. His experiments with Folse in mobilization of the human trachea in the pathology laboratory, along with those of Dr. Michelson and his colleagues at Hopkins, have also been of great interest to us. We have found less variability with age in 40 dissections in adults between 33 and 88 years. We have not regularly measured tensions in the operating room. In the case which I showed you, the tension determined by very simple measurement, was less than 800 Gm. In such measurement one may forget that direct pull also records the deadweight of the unventilated lung. The buoyancy of saline in the chest cavity or a supporting hand may approximate the air-filled lung more accurately; the tension is remarkably less.

Dr. Brewer's comments were most interesting. The anesthetic technic which we have evolved with Dr. Henrik Bendixen avoids relative oxygen unsaturation during the various stages of the operation and makes it possible to move with deliberation in an unhurried fashion. Far from being complicated, we consider this method to be a simple and direct approach.

The question of closure with patches and grafts has intrigued us. Patches obviously heal in different ways. I think the evidence is clear that in some cases healing of such defects is by the process of contraction. If there is any regeneration it occurs by the process of intussuceptive growth, as Medawar termed it. This is similar to what Dr. Dunphy and his group described this morning.

One last comment on the matter of secretions. We were pleased to find, in the cervical replacements, that total replacement with nonrespiratory epithelium is well accepted. This could have been predicted from other replacements—with solid prostheses or with skin tubes such as Dr. Edgerton has described. It seems that the lower one goes in the trachea the less easily the tracheobronchial tree clears secretions. In the upper trachea the secretions are mobilized to that point by the usual mechanism and then cleared very easily with a cough.