

TRACHEOTOMY IN LEPROSY*

By

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I. INTRODUCTION

Leprous involvement of the larynx, necessitating tracheotomy as a life-prolonging procedure, is common in the lepromatous form of the disease; it is so common that at Kalaupapa Settlement 13.1 per cent of active patients are wearing tracheal tubes.** As textbooks devote little or no attention to

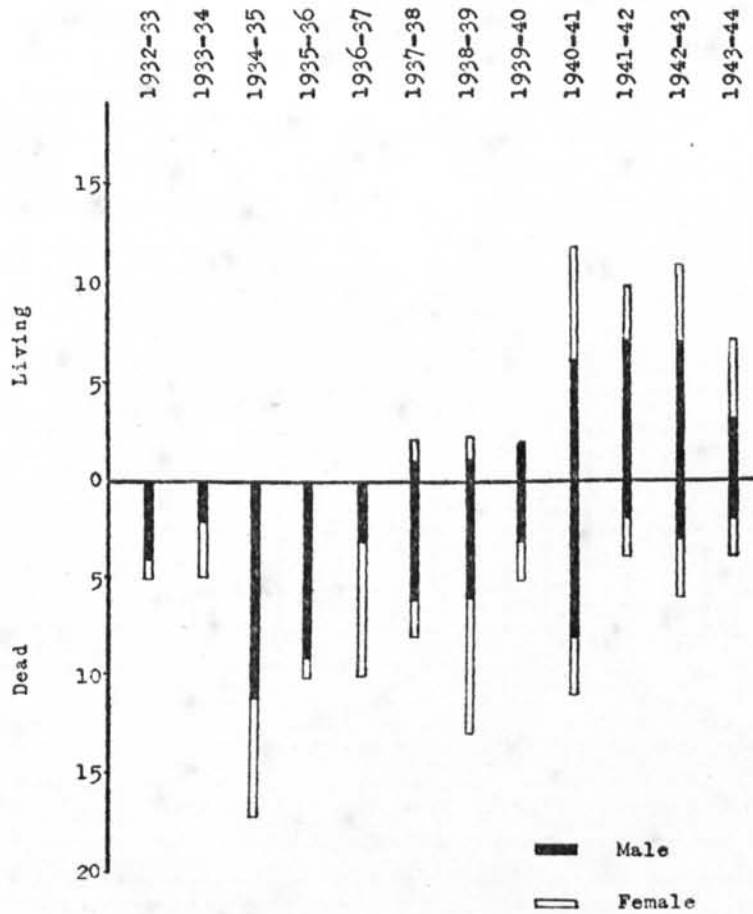


FIG. 1. Present status of 144 patients, by sex and year of operation.

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** All figures are as of June 30, 1944.

this subject, this article is presented in the hope that our experience will be of value to others.

II. CASE MATERIAL

In a 12-year period 146 operations have been performed on 144 patients. Of these, I have done 43 during the last 4 years, including all but one since July 1941. On this material, graphically summarized in figure 1, this study is based.

Of the 144 patients 46 are living, 27 of whom are males and 19 females; 98 are dead, of whom 58 were males and 40 females. The proportion for each sex is as expected; the usual ratio at this settlement is about 3 males to 2 females. The interval between first commitment and operation is shown in figure 2. The average is 12 years, 3 years longer than the average life of

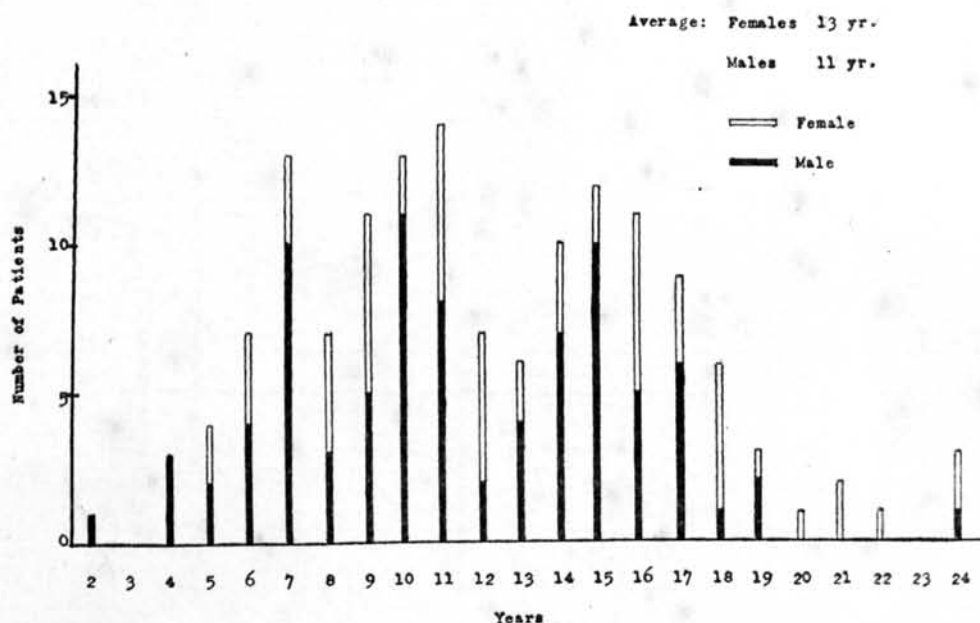


FIG. 2. Time from first commitment to operation.

all lepromatous cases. This does not mean that presence of a laryngeal lesion prolongs life; it rather seems to indicate that most lepromatous patients do not live long enough to develop laryngeal stenosis. This is borne out by finding that of 32 lepromatous patients now living, whose first admission was prior to July 1, 1929 (15 years ago), 16, or 50 per cent, are now wearing tracheal tubes; and of the remainder 7 show evidence of laryngeal leprosy which may require operation later.

Age at operation, by 5-year periods, is shown in figure 3. The distribution is about what would be expected in view of the foregoing and the well-

known tendency of first signs of leprosy to appear in adolescence or early adult life.

Three patients discontinued use of their tubes. One who used his only a month lived 4 years and died of nephritis; probably the operation was not

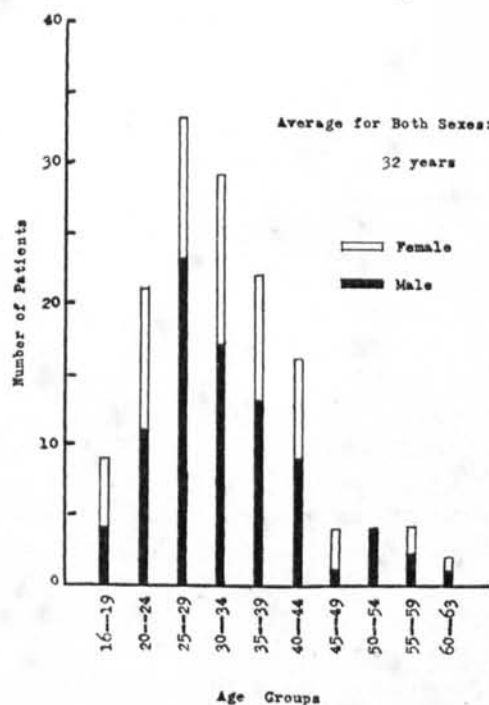


FIG. 3. Age at operation.

necessary. The second required re-operation after 8 months; it is not known at what time the tube was removed. The third wore his tube about two years; a second operation was needed two years after removal.

III. PATHOGENESIS

Leprotic laryngitis is found only in lepromatous patients, usually in those who first present lesions of the mouth or pharynx. The epiglottis is first involved and may become several times normal size; spread to the vocal cords produces gradual narrowing of the glottis, which may become so small that slight swelling of the mucosa can obliterate it and cause death. The narrowing of the glottis causes increased respiratory effort, and perhaps at times mild bronchiectasis. Bronchial secretions are expelled with difficulty, and their accumulation increases the dyspnea, producing a vicious cycle which can be broken only by providing an adequate airway.

IV. SYMPTOMATOLOGY

A. Symptoms

Hoarseness is the first symptom, which may be present for months or years before operation is required. It is, however, a danger signal, and persistently hoarse patients should be carefully studied.

Dyspnea is both a symptom and a sign. At first the patient notices "tightness," particularly when suffering from a cold; there may be periods of remission, but the trend is toward increasing severity. As the condition becomes worse wheezing respiration appears, often audible at a distance. When operation is deferred, actual "choking spells" occur, particularly in periods of cold or damp weather, when laryngeal edema may occur. It is well not to wait for these, as occasionally the first is fatal.

B. Signs

Dyspnea: see above. When acute, respiratory movements are rapid and forced, and the condition somewhat resembles bronchial asthma.

Retraction of supra-sternal and infra-sternal regions occurs on forced inspiration.

Rales are heard throughout the chest, especially in the lower lobes. They are caused principally by accumulated mucus, and vary in character depending on location and amount of mucus present.

X-ray of chest shows increase in broncho-vascular markings, also most marked in the lower lobes. This adds little to clinical information, but may be of value in persuading the patient that operation is needed.

Indirect laryngoscopy shows a large and frequently nodular epiglottis, which may prevent visualization of the glottis. If the larynx is clearly seen, the appearance of the vocal cords is completely changed; usually all one sees is swollen tissue surrounding a small and narrow opening, if any opening at all is visible. (At times small discrete nodules are seen on the vocal cords in relatively early cases.)

V. INDICATIONS AND CONTRA-INDICATIONS

The indication for tracheotomy is gradually increasing hoarseness and dyspnea. Most patients will not consent to surgery until after one or more acute episodes, known locally as "choking spells." However, operation is advised as soon as signs and symptoms are definite; in our experience patients who wait as long as they dare have more stormy convalescence than those who receive early attention, and their post-operative life expectancy is less. Moreover, it is advisable to operate while the voice is in fair condition; a lost voice probably will not be regained.

No absolute contra-indication is recognized, if dyspnea is sufficiently severe. It is better to defer operation if possible in cases of skin infection and acute febrile conditions. Tuberculosis and pregnancy are not contra-indications; but delivery is more difficult in a patient wearing a tracheal tube,

because she is unable to bear down well. Elective Caesarean section and sterilization may be considered.

VI. PRE-OPERATIVE PREPARATION

When operation is deferred, because of mildness of symptoms, intercurrent disease, or the patient's desire, dyspneic attacks may at times be relieved by injection of 0.5 cc. of solution of epinephrin, 1:1000 ("adrenaline"). This is also given to patients admitted with dyspnea, while preparation is made for operation. It is my practice, however, not to defer operation when indications are definite and the patient's consent has been obtained.

Morphine sulfate, 15 mg. (gr. $\frac{1}{4}$), or less for a frail or light patient, is given about 45 minutes before operation. This is contrary to advice sometimes given; but experience here indicates that it is important to allay apprehension, while the cough reflex remains, sometimes stronger than one wishes. Hypnotics are contra-indicated, as a conscious and cooperative patient is desired. Morphine is given even when the patient's condition does not permit waiting the usual time, as its effect is also of value for the postoperative period.

Unless the skin of the neck is grossly infected, simple preparation with soap and water followed by a mercurial antiseptic is sufficient.

VII. SURGICAL ANATOMY

It is well to consult the books, and to have in mind a general picture of the anatomy at the thyro-tracheal region, but for practical purposes only a few points are important. Surface landmarks are easily identified. With the head thrown back, the thyroid cartilage is always palpable, often visible. The cricoid cartilage is easily palpable except in very fat necks, and is sometimes visible. The trachea is readily held between the fingers, and at times individual rings may be felt. The isthmus of the thyroid gland is usually not palpable, and its position will be determined only after it is exposed by separation of the overlying muscles. Even then its identification may be difficult.

The operative procedure is confined to the midline of the neck, where no large vessels or nerves are encountered, and bleeding, except at times in the thyroid gland area, is easily controlled. The operative field consists of four layers:

First layer: skin and superficial fascia. Occasionally platysma fibers may be seen; if so they are ignored. Vessels are small and rarely require ligation.

Second layer: muscle. Usually the sterno-hyoid and sterno-thyroid muscles of the two sides are in fairly close contact in the midline of the neck. Occasionally this contact is so intimate that it is difficult to find the dividing raphe. Rarely the muscles will be so widely separated that they are not even seen. They are covered by a rather tough fascial layer. A single vein is sometimes present in the midline, possibly replacing the usually paired anterior jugular.

Third layer: deep fascia and thyroid isthmus. Beginners beware! The isthmus of the thyroid gland at times looks surprisingly like muscle; while if covered by dense fascia it may be invisible. It is often most easily identified by touch; but tracheal rings may be palpated through it. It may be thick, thin, or absent. Its position varies considerably, but it is most often just where one wishes to incise the trachea—over the second and third rings. Usually it must be severed before incising the trachea.

The upper edge of the isthmus is connected to the cricoid cartilage by a fascial sheet which may be thick or thin but is always vascular. The lower edge is connected to the trachea by looser connective tissue.

Fourth layer: trachea. The deep fascia covering the trachea is tightly adherent, and no effort is made to dissect it away. The tracheal rings can be both felt and seen. The posterior wall of the trachea is not cartilaginous and is markedly vascular; therefore one is careful not to nick it and so cause bleeding which would be difficult to control. It seems hardly necessary to caution against cutting so deeply that one penetrates the esophagus or a vertebral artery; but it is said to have happened!

VIII. OPERATION

Position: Except for emergencies in which there is no time to control hemorrhage, a semi-sitting position is used, with the patient's neck extended by placing a hard pillow under the shoulders. This is more comfortable for both patient and operator than the supine position usually recommended. (One book says "prone," but surely does not mean it!)

Anesthesia: Regional anesthesia is employed, using a rhomboidal block of $\frac{1}{2}$ per cent procaine hydrochloride ("novocaine") with 3 or 4 drops of solution of epinephrin, 1:1000, per ounce. The midline of the neck represents the long axis of the rhombus. Some advocate additional intra-laryngeal and intra-tracheal instillation, but this does not seem necessary, and I feel that the theoretical advantages are more than upset by the discomfort to the patient of the Rose position. (A recent report indicates that intra-tracheal instillations may even endanger life.) It is advisable if possible to avoid injecting the midline of the neck, as this produces edema and to some extent may obscure surgical landmarks. Occasionally a few extra drops of anesthetic will be required under the isthmus of the thyroid gland, after it has been exposed.

General anesthesia is, of course, contra-indicated in any case of laryngeal stenosis.

Draping: This is decided by individual preference, but should be so arranged that the patient cannot see the operation, but is able to sit up as soon as the tube has been inserted. The operator and assistant wear sterile gowns, largely for their own protection, and headgear which covers as much of the face as possible. Goggles are advisable for workers who do not wear

glasses, to protect the eyes when the patient coughs. (A new type of mask, resembling a welder's helmet, is made of transparent plastic. It is not optically perfect, but offers good protection.)

Armamentarium: The contents of the "tracheotomy tray," as used at Kalaupapa Settlement, are listed in table 1. This tray is always ready for immediate use, and the instruments are promptly cleaned and resterilized after each operation.

TABLE 1. *Contents of tracheotomy tray*

2	Bard-Parker type knives, no. 10 blade (1 blade new)
1	Mayo dissecting scissors, straight, 5½ inch
1	Mayo dissecting scissors, curved, 5½ inch
4	Halsted mosquito forceps, curved
4	Halsted mosquito forceps, straight
4	Kelly artery forceps, curved, 5½ inch
1	Trousseau tracheal dilator, thin blades
5	Towel clips
1	Eye speculum, wire
3	Retractors, small, Desmarre eyelid type
1	Hook, sharp
2	Allis tissue forceps
1	Thumb tissue forceps, 4½ inch
1	Grooved director
1	Medicine glass, 1 oz., for procaine solution
1	Luer syringe, 5 cc.
2	Hypodermic needles, 1 inch, 24 gauge
2	Surgeon's needles, ¾ inch, curved, taper point
	Jackson tracheal tubes, lubricated, sizes 4, 5, 6
6	Towels
18	Gauze sponges
	Procaine hydrochloride, ½ per cent solution, with solution of epinephrin (1:1000)
	3-4 drops per ounce
8	Cotton tipped applicators
	Sulfanilamide crystals, sterile
	Catgut, 00 plain

The wire eye speculum is used as a self-retaining retractor. The blades may be straightened somewhat to care for the thickness of tissue encountered. It functions well and enables good visualization throughout the operation.

The Trousseau dilator is almost indispensable; it is easily inserted and holds without slipping, and the tube is readily inserted while it is in place. In a good instrument the combined thickness of the closed blades is about 3.5 mm. Thicker blades are less satisfactory.

Three sizes of Jackson type tracheal tubes are kept on hand: 4, 5, and 6. (To find the approximate outside diameter in millimeters add 5 to the size.) Our patients for the most part preferred aluminum tubes, as they are lighter than silver ones and seem to cause less metallic taste; but the silver tubes are much more durable, and since the war have been the only ones obtainable.

If a silver tube is used at the time of operation, most patients find it satisfactory; and in the end it is probably cheaper. Size 5 is suitable for most patients. At times a patient who has worn a tube for a year or two will then accommodate a larger size with comfort. Gauze tapes are threaded through the slits of the tube before sterilizing.

The scalpel preferred is of the Bard-Parker type, size 10 blade. An unused blade is reserved for the tracheal incision.

Operative technic: The operation proceeds in four steps, corresponding to the anatomic layers. These are: (1) incision of skin and fascia; (2) blunt dissection and separation of muscles; (3) disposal of the isthmus of the thyroid gland, by division, retraction, or both, and (4) incision of the trachea and insertion of the tube.

(1) The operator, if right-handed, stands on the patient's right, and holds the trachea between the thumb and forefinger of his left hand, to steady the

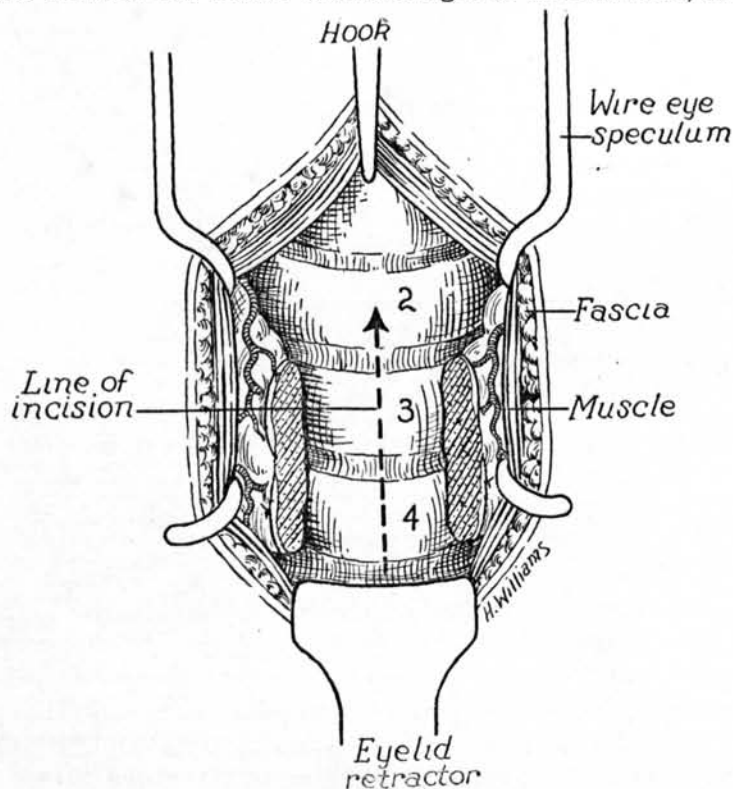


FIG. 4. Illustrative sketch of operative field.

the cricoid. This is deepened to the fascia covering the muscle layer, and trachea and skin and to establish the midline for incision. This maneuver is frequently useful during the operation, especially if there is doubt about the midline position. The thyroid and cricoid cartilages are identified by palpation, and an incision about 3.5 cm. long is made downward from the level of

small vessels are clamped. Sometimes a tie will be required, but usually a few minutes clamping suffices, except for the venous jugular arch, which if encountered should be ligated.

(2) The eye speculum is inserted, with the closed end cephalad, retracting the skin and fascia and making the muscle layer clearly visible. The mid-

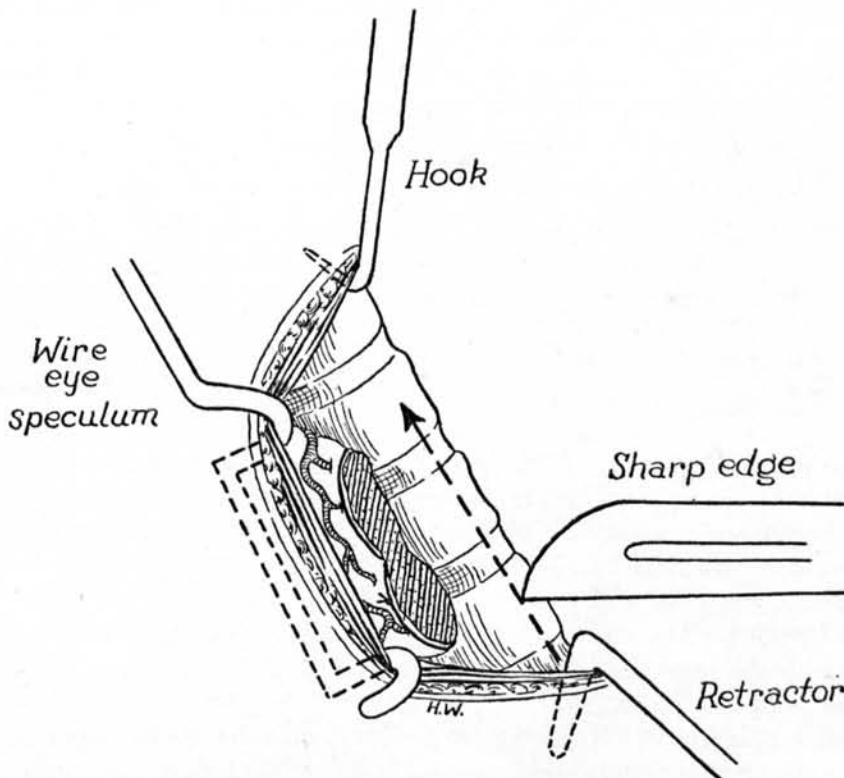


FIG. 5. Position of instruments in cutting tracheal rings.

line raphe between the muscles is incised, and division of the fascia completed with scissors; the muscle bodies are then separated from each other and from the underlying fascia by blunt dissection, using the straight dissecting scissors. The two muscles on each side (if both are seen) are treated as one. The speculum is now reinserted to retract the muscles, thus exposing the thyroid isthmus and underlying trachea. At times an Allis forceps will aid in grasping the muscle and lifting it to permit placing of the speculum.

(3) Unless the isthmus is easily displaced—which is rarely the case—it is my practice to cut it sufficiently to expose the second and third (or third and fourth) tracheal rings. Curved or straight Halsted forceps are placed and the gland cut between them with scissors (not a knife), transfixed, ligated, and the clamps removed. The ligature is left long until it is certain that bleeding is controlled. Depending on the anatomic relations, the isthmus

may be completely severed, or partially severed and the remainder retracted. This is a matter of judgment, so long as one secures adequate exposure of the tracheal rings.

(4) The sharp hook is caught under the lower edge of the cricoid cartilage, in the midline, and held by the assistant's right hand, lifting it upward and forward and thus steadying the trachea for incision. The small eyelid retractor is held by the assistant's left hand, in the lower angle of the wound. The isthmus, if not completely severed, is held by one of these instruments. If completely severed it usually requires no further retraction, but if necessary may be included in the hold of the wire speculum.

All bleeding is controlled before the trachea is incised.

Fixing the trachea with his left hand, as described under (1), the operator takes the scalpel in his right hand, with the sharp edge up, inserts the point below the lowest ring to be cut, and cuts upward, gently and smoothly, through two rings, or occasionally through three. It is essential that the trachea be firmly held, so that the incision may be made cleanly through fascia, cartilage, ligaments, and mucosa, but without nicking the posterior wall.

The operator now takes the Trousseau dilator in his right hand and the tracheal tube in his left. (It is preferable to insert the tube as it is to be worn, double and without the obturator.) The blades of the dilator are inserted into the tracheal incision and separated. The patient can now breathe through the opening, and retractors may be carefully removed before the tube is inserted. The end of the tube is then slid between the blades of the dilator into the trachea. The dilator is removed, the patient sits erect, and the tube is tied in place.

This leaves the visible portion of the tracheal tube in the upper part of the incision, which is left open, primarily to prevent development of subcutaneous emphysema. (It soon closes around the tube.) Sulfanilamide crystals are dusted into the incision; folded gauze squares are placed at each side, under the tape, overlapping the incision, and another is hung over the opening.

COMMENTS ON OPERATION:

Incision: The incision sometimes recommended, from the thyroid cartilage to the suprasternal notch, is unnecessarily long. Sufficient room to insert the speculum is all that it required.

Thyroid isthmus: This structure is the chief cause of hemorrhage during and after the operation. Any approach to it is likely to cause bleeding, and it is most important that this bleeding be controlled before the trachea is opened. It may be difficult to do so later.

If a scalpel is used to cut the isthmus, there is danger of incising the underlying trachea prematurely. This might cause coughing, or bleeding

into the trachea, either of which would interfere with the smooth progress of the operation.

Deep fascia: Dissection of deep fascia from the trachea would cause unnecessary bleeding. With a clean incision through fascia and tracheal wall, bleeding is negligible.

Opening the trachea: At times the transition from obstructed to easy breathing is so abrupt that the patient may seem to have stopped breathing. It is said that actual reflex apnea may occur, but I have not seen it. More often there will be a sharp cough in an effort to expel the accumulated mucus, which is sometimes so thick that some can be extracted with forceps.

Removing retractors: It is possible to do this after the tube is inserted, but more difficult. One annoying post-operative hemorrhage was apparently caused by the point of the wire speculum catching in friable tissue. Care must be taken, however, that the trachea does not slip off the dilator.

Recapitulation: The essentials of a satisfactory operation are: position of patient; adequate regional anesthesia; clean dissection in the midline of the neck; complete hemostasis before opening the trachea; full vision for the whole procedure, especially the tracheal incision; a clean tracheal incision and smooth insertion of the tube. Usually there is no race for time; a good operation may take ten minutes or thirty, and no one can tell in advance which it will be. (The longer period is more common; and my most difficult case took 65 minutes, with enlarged lymph nodes obscuring the operative field.) As in all surgery, there is no substitute for experience, and each repetition of the operation teaches something new.

IX. POST-OPERATIVE CARE

The doctor explains to the patient somewhat as follows:

"When people are breathing naturally, the air goes through the nose and is warmed and moistened, and dirt is filtered out. A tracheal tube makes a short circuit. In this climate the air is naturally warm and moist for the most part, but if there is irritation or drying we will use steam inhalation to make you more comfortable. But it is very important to keep dirt out at all times. So you should always have the opening of your tube covered with gauze or a clean handkerchief, and never put anything in it except air."

Routine post-operative orders:

- I. Semi-sitting position for first day, longer if desired.
- II. Codeine sulfate 30 mg. (gr. $\frac{1}{2}$) by mouth, before meals and as required for 3 days.
- III. Liquid diet first day, but if patient feels comfortable and able to swallow, soft foods may be given. After first day, diet according to patient's wishes.
- IV. Clean inner tube frequently.

- V. Change gauze over tube as required.
- VI. Attention to incision—watch for infection. Sulfanilamide crystals or powder if required.
- VII. Encourage patient to swallow normally.
- VIII. No speaking the first day; after that encourage it, holding the finger over tube opening to aid phonation if necessary.
- IX. Outer tube is left in place for 5 days, after which the first change is made by the surgeon. After this the nurse changes it twice a day, and the patient soon may be taught to change his own if he wishes.

Many patients soon go on a daily tube changing schedule, some even less frequent. After the first change a handkerchief folded diagonally is tied around the neck to cover the tube, instead of gauze. Each patient is provided with two tubes, so that one may be cleaned while the other is being worn.

In the hospital one nurse is assigned to changing all patients' tubes. To prevent confusion a small glass jar is assigned to each patient and marked with his name. His soiled outer and inner tubes are separated and placed in a solution of soft soap in his jar for an hour or two, then cleaned with a brush and running water. After rinsing and drying them, new tapes are inserted and the reassembled tube is replaced in the dried jar, to be lubricated just before the next insertion.

Usually for the first few days after operation the patient will bring up a large quantity of mucus which has been trapped in the bronchial tract. While this is desirable, excessive coughing is distressing, and may lead to bleeding. We therefore use codeine routinely but with judgment.

Swallowing is often difficult at first, although some patients have no difficulty. All are advised to eat slowly and to take small mouthfuls, and most are ready for full diet by the third day.

Thick mucus easily blocks the tube, and frequent cleaning is required for the first few days. For this purpose a special brush is preferable, but it is very difficult to obtain satisfactory ones. Ordinary cotton wrapped wooden applicators may be used, if special care is taken to see that no pieces break off and remain inside the tube. One avoids scratching the inside of the tube, as this makes thorough cleaning more difficult. *The tube is never cleaned in situ*; the inner tube is always removed for this purpose.

In 5 days the tube tract is fairly well established. The patient sits on a chair or upright in bed, with the chin slightly raised, and tries to relax; the doctor cleans the skin around the tube with hydrogen peroxide, paints it with a mild antiseptic solution, then gently removes the tube, observing the direction in which it comes out most easily, and without force inserts a new one of the same size and shape. Usually it is not necessary to use an obturator, but this is done if the new tube does not slip in easily. (Since our aluminum tubes are not furnished with obturators, a soft rubber catheter may be used

instead.) Very rarely it might be necessary to reinsert the Trousseau dilator; this has happened only once in over sixty cases.

The immediate relief obtained from the operation is striking, even in many in whom obstruction was far from complete. The usual patient reaction is, "I wish I had had it done months ago." Rare indeed is the patient who after operation thinks he should have waited longer.

It is advisable, though not essential, in the early weeks to employ steam inhalations 2 or 3 times a day. A mild medication may be added, such as tincture of benzoin compound or oil of eucalyptus, but the effect of these is probably largely psychic. We use the Colson Safety Inhalator (Colson Company, Elyria, Ohio), which rests on the floor, but simpler and even makeshift arrangements are usable if proper precautions are taken against burns.

Probably the greatest single factor in avoiding post-operative bronchial complications is avoidance of trauma. In the past some patients were addicted to pushing soft rubber catheters down the trachea, and spraying with various solutions. Now that education is overcoming these abuses our patients are living longer and more comfortably.

X. OPERATIVE MORTALITY

Tracheotomy should prevent death, not cause it. Still, one may be compelled to operate on patients who are moribund, because of operation too long delayed or intercurrent disease; or in a field so badly infected that systemic spread of the infection cannot be prevented. (The advent of the sulfonamides has of course greatly altered the prognosis, and penicillin will probably do still more.)

TABLE 2. *Causes of death occurring post-operatively and subsequently for 98 leprosy patients*

	Post-operative	Other	Total
"Tube deaths"	—	26	26
Leprosy	2	24	26
Tuberculosis, pulmonary	—	13	13
Cardiac (and cardio-renal) disease	3	6	9
Pneumonia	2	5	7
Nephritis	1	2	3
Laryngeal stenosis (operation too late)	2	—	2
Tuberculosis, lymph node	—	2	2
"Septicemia"	—	1	1
Cellulitis	1	—	1
Gastro-enteritis	—	1	1
Hepatic cirrhosis	—	1	1
Not known or doubtful	3	3	6
	14	84	98

In this series of 144 cases, 14 died within 2 weeks of operation, a post-operative mortality of 9.7 per cent, startlingly high at first glance. Records are

incomplete on the earlier cases, and in some the actual cause of death is uncertain. The apparent causes are listed in table 2 for the entire group, with post-operative deaths tabulated separately. Brief summaries are given of cases dying post-operatively, as far as records are available. The last 5 came under my direct observation.

Case 2549, male, age 28. Period of commitment 7 years.

He was admitted to the Settlement hospital February 5, 1933 complaining of dyspnea. February 7, he left against advice, but returned February 9. February 25, tracheotomy was attempted at 5:30 a.m., but not completed because of severe bleeding. At 8:30 a.m. tracheotomy was again attempted and this time completed, but respiration had stopped and pulse was not palpable. Epinephrin and artificial respiration were employed, with effect in 1 hour. He did not regain consciousness, and died at noon.

Comment: The operation should have been performed at the first admission, if not sooner. Later, when an attempt was made, bleeding should not have stopped it. (An emergency in which the patient is choking is the time for Jackson's method: ignore the bleeding and locate the trachea by palpation.)

Cause of death: Laryngeal stenosis, operation too late.

Case 2212, female, age 40. Period of commitment 10 years.

Tracheotomy was performed April 3, 1933 because of dyspnea. She died April 12. No details are given; cause of death is said to be "Leprosy, advanced severe."

Comment: One can only speculate, but this would appear to be a case of operating on a dying patient.

Cause of death: Doubtful.

Case 2837, female, age 35. Period of commitment 14 years.

She was admitted to the hospital May 8, 1935 *in extremis*. (Her condition had been hidden from the doctor while she remained in her quarters.) She had advanced lepromatous leprosy, possibly syphilis, a severe infection of the right hand exposing the bones, a possible bleeding gastric ulcer, and laryngeal obstruction. She demanded tracheotomy, which was done; and she died the following morning.

Comment is superfluous!

Cause of death: Leprosy.

Case 1556, male, age 31. Period of commitment 19 years.

Tracheotomy was performed July 31, 1935 for dyspnea. "Patient felt better for a few days. He became very weak and decompensation set in" on August 6. He died the next day "of advanced leprosy."

Comment: Not justified by the available evidence.

Cause of death: Doubtful.

Case 2742, male, age 53. Period of commitment 15 years.

Tracheotomy was performed September 4, 1935 because of laryngeal dyspnea. He died 8 days later of "advanced leprosy and edema of the larynx."

Comment: As far as can be determined, the true cause of death appears to have been bronchopneumonia.

Cause of death: Doubtful.

Case 2289, male, age 35. Period of commitment 15 years.

He suffered from severe cardio-renal disease, including ascites. There is no record of laryngeal involvement, but tracheotomy was performed January 21, 1938. He died 2 days later.

Comment: Cardiac decompensation is not an indication for tracheotomy!

Cause of death: Cardio-renal disease.

Case 2026, female, age 31. Period of commitment 18 years.

For about 2 years she was known to have suffered from chronic nephritis. Since there was "some degree of laryngeal stenosis," tracheotomy was performed March 15, 1939, but she died 2 days later.

Comment: It is hard to say whether this operation should have been performed. Perhaps it was justified for the patient's comfort; it certainly had no effect on the outcome of the case.

Cause of death: Nephritis.

Case 2791, male, age 52. Period of commitment 11 years.

He was admitted to the hospital March 16, 1939 complaining of fatigue, later of dyspnea. Heavy albuminuria was present. Tracheotomy was performed April 6; no reason for the operation is stated. He died 10 days later; cause of death is given as cardio-vascular-renal disease.

Comment is again superfluous.

Cause of death: Cardio-renal disease.

Case 2928, male, age 16. Period of commitment 11 years.

Statement on death: "He died June 16, 1940 of advanced cutaneo-neural leprosy and bronchopneumonia. He had laryngeal obstruction due to leprosy and an emergency tracheotomy was performed June 12, 1940. This contributed to his death.

"During the past year he has experienced difficulty in breathing, due to laryngeal leprosy, on several occasions." No further record is available.

Comment: He is said to have died of bronchopneumonia, 4 days after operation. Did the pneumonia precede or follow the tracheotomy?

In any case, it is obvious that the operation should have been performed many months sooner. Perhaps the patient had refused; if so, this should appear on the record.

Cause of death: Bronchopneumonia.

Case 3239, male, age 37. Period of commitment 7 years.

He showed a rapidly advancing lepromatous leprosy, and died of leprous cachexia. There was some laryngeal involvement, but dysphagia was more prominent than dyspnea. On January 27, 1941 he demanded and obtained tracheotomy. The operation had no effect on the disease; he died 3 days later.

Comment: There was no indication for this operation except the patient's desire. Perhaps it should have been refused; at times this is a most difficult decision.

Cause of death: Leprosy.

Case 3238, female, age 23. Period of commitment, 9 years.

She was admitted to the hospital January 5, 1943 for elective tracheotomy. Pre-operative x-ray showed only the usual increase in basal markings. She was extremely nervous during the operation in spite of sedation. There was considerable fat, and bleeding was difficult to control. The following morning she was seen to be acutely ill; temperature rose to 105 F. (40.5 C.) and she suddenly stopped breathing. Necropsy

showed bronchopneumonia apparently limited to the lower lobe of the left lung, and no other significant findings.

Comment: This case remains a puzzle. Did she have pneumonia before operation? Was it sufficient to account for her death? Did we miss something? Perhaps this is the one case in the series in which death was caused by the operation.

Cause of death: Bronchopneumonia?

Case 3205, male, age 27. Period of commitment, 10 years.

He was admitted to the hospital December 13, 1942 with badly infected extensive ulcerations of both legs. At this time he showed laryngeal dyspnea, and operation was advised, but he refused until February 12, 1943. The operation was made hazardous by infected skin of the neck, and in spite of local use of sulfonamides, the wound became infected. Other lepromatous ulcerations developed, and he died of leprous cachexia.

Comment: There is no real evidence that the operation contributed to his death, or that earlier operation would have prolonged his life. In a similar situation now, one might try to control the secondary infections with parenteral penicillin. I believe this operation was justified for the patient's comfort.

Cause of death: Leprosy.

Case 3121, female, age 41. Period of commitment 17 years.

For several years she was known to have had severe anemia (apparently caused by nosebleeds for which she never accepted adequate treatment), cholelithiasis, and chronic nephritis. She had obvious laryngeal stenosis for more than two months prior to hospital admission, but persistently refused tracheotomy. October 28, 1943 she was admitted with severe cellulitis of the right hand and arm, which was the immediate cause of her death. It became evident on October 31 that she would suffocate unless tracheotomy was performed, and she at last consented, but died the following day.

Comment: Obviously, the operation had no effect on the outcome, but she might have had better resistance had it been performed sooner. Penicillin was not available; combined with the operation it might have saved her life.

Cause of death: Cellulitis.

Case 3602, male, age 46. Period of commitment, 4 years

He was admitted to the hospital January 14, 1944 with dyspnea which appeared to be caused by a combination of mitral insufficiency and leprous laryngitis. Tracheotomy was performed a few hours after admission, and gave marked relief, but on the following day he became decompensated and died.

Comment: It seems fair to regard this as a cardiac death, but it must be admitted that it was unexpected. Certainly the operation was indicated; perhaps pre-operative digitalization should have been employed.

Cause of death: Heart disease.

XI. POST-OPERATIVE COMPLICATIONS

"Choking spells." When the patient comes to operation his lungs are not normal. The gradually contracting laryngeal orifice has required increased pulmonary efforts to obtain enough oxygen, especially when exercise increased the demand. The accumulation of thick mucus in the trachea and bronchi, and choking caused by laryngeal congestion and edema, add much

to this. In consequence we expect a certain amount of pulmonary congestion, bronchiectasis, and emphysema to be present, and this is frequently shown by an increase in the lower lobe markings in pre-operative x-rays.

If the operation has not been too long delayed and the patient is in reasonably good condition, relatively normal pulmonary function will be reestablished and may last for years. In time, however, a condition of "chronic bronchitis" occurs, with excessive mucus, crusting, and edema. The crusts become detached and form partial obstructions, with coughing and choking and further edema. These "choking spells" may be mild or severe; they tend to become worse, and eventually cause death. Thus if the patient does not die of intercurrent disease he may expect a "tube death." For this reason those patients whose death certificates read "chronic bronchitis due to indwelling tracheal tube" live longer, on the average, than those dying of other causes. (3 years 1 month for "tube deaths;" 1 year 7 months for others.)

Care of patients who are choking is a most important part of the nursing service. The following instructions are posted on the door of the hospital medicine cabinet; often there is no time to call a doctor!

EMERGENCY INSTRUCTIONS

Tube Cases — Choking spells

- I. Steam inhalations. Start early; don't wait for choking. (Care to avoid burns.)
- II. If possible, give propadrine 2 capsules (gr. $\frac{3}{4}$ stat.)
- III. Adrenalin (see note) $\frac{1}{2}$ cc. hypodermically. May be repeated if necessary every $\frac{1}{2}$ hour up to 4 doses.
- IV. Morphine sulfate gr. $\frac{1}{6}$ (gr. $\frac{1}{4}$ if patient is very heavy) *only if attack continues.*
- V. *Last resort*—suction with a sterile catheter. Usually no help.

Note: Adrenalin is also known as epinephrin (official name), adrennin, adrin, suprarenin, and suprarenalin. *Do not confuse with ephedrine.*

COMMENT: If an actual plug is present, its removal gives relief, and it is here that suction may be of value; but suction will make edema worse. If choking is due to edema, epinephrin injections frequently help. Morphine is given only to prevent exhaustion; it is possible that demerol will largely supplant it.

Often patients complain of "tightness" in the chest, and prompt attention may avert a choking attack. Capsules of propadrine hydrochloride, gr. $\frac{3}{8}$ or $\frac{3}{4}$ (25 or 50 mg.), or ephedrine and seconal, 1 or 2 capsules (each capsule contains ephedrine sulfate, gr. $\frac{3}{8}$ —25 mg.—and seconal sodium gr. $\frac{3}{4}$ —50 mg.) are often effective and are known to the patients as "chest capsules."

Demerol (isonipicaine) is a relatively new synthetic drug which is said to have a morphine-like action on pain, but relaxes bronchial muscle. It is

effective both by mouth and hypodermically. A limited trial indicates that it will probably be of value in these cases.

Where available, inhalation of carbon dioxide, 5 per cent in oxygen, will sometimes help to loosen the thick mucus which is often so troublesome post-operatively. Our experience with this agent is limited.

Loss of voice: Usually the rest afforded the larynx by operation results in preserving what vocal ability remains, and sometimes there is considerable improvement. At times, especially if operation is too long delayed, aphonia develops, as in 2 of our 46 living patients.

Excess granulation: In some patients there is a tendency for granulation tissue to form around the opening. This may be sufficiently bulky to interfere with changing the tube. It is readily trimmed with scissors, the patient being in a sitting position to prevent aspiration of blood. No anesthetic is needed, and bleeding is readily controlled by pressure.

XII. CAUSES OF DEATH

Again referring to table 2, it is seen that of the 84 patients who survived the operation by more than 2 weeks, but have since died, 26 are listed as "tube death." In a sense these are deaths due to leprosy, as they are indirectly caused by the laryngeal lesion which necessitated tracheotomy. However, when leprosy is listed as the cause of death, one pictures the chronic wasting disease, often complicated by hepatic, splenic, and renal amyloidosis and by terminal diarrhea. (Perhaps the case listed as gastro-enteritis also belongs to this group.)

A startling finding is the low number of deaths (15, or 18 per cent) from tuberculosis, which is about half the rate for the settlement at large. Perhaps the explanation is that tuberculosis attacks younger patients, who either recover or die before reaching the stage of laryngeal stenosis. No statistics are available on this. Another (perhaps remote) possibility is that the covering worn over the tube opening helps to prevent inhalation of tubercle bacilli.

The remaining causes of death might occur in any group, and it is probable that the presence of a tracheal tube had little or no influence on them.

XIII. CONDITION OF LIVING PATIENTS

The 46 living patients were classified as to the degree of difficulty resulting from use of the tube, from "0" (fully satisfactory function) to "4" (severe distress, perhaps moribund). These are summarized in table 3.

There is no correlation between a patient's condition and the time the tube has been worn. Difficulty may start a few months after operation, or there may be none for several years. An "0" patient has worn his tube more than 6 years; a "4" patient, less than 2 years.

Three patients have pulmonary tuberculosis; 2 have lymph node tuberculosis; and 4 are blind.

TABLE 3. *Present status of living patients, by sex*

(See text for explanation)			
Group	Male	Female	Total
0	11	9	20
1	9	5	14
2	4	3	7
3	2	1	3
4	1	1	2
	27	19	46

XIV. A LOOK AHEAD

Our data clearly indicate that the patients are living longer; it is particularly interesting to note that the average length of life to date of living patients is greater than that of those who have died. This is graphically summarized in figure 6. It should be interesting to restudy the question 5 or 10 years hence to see whether this trend continues.

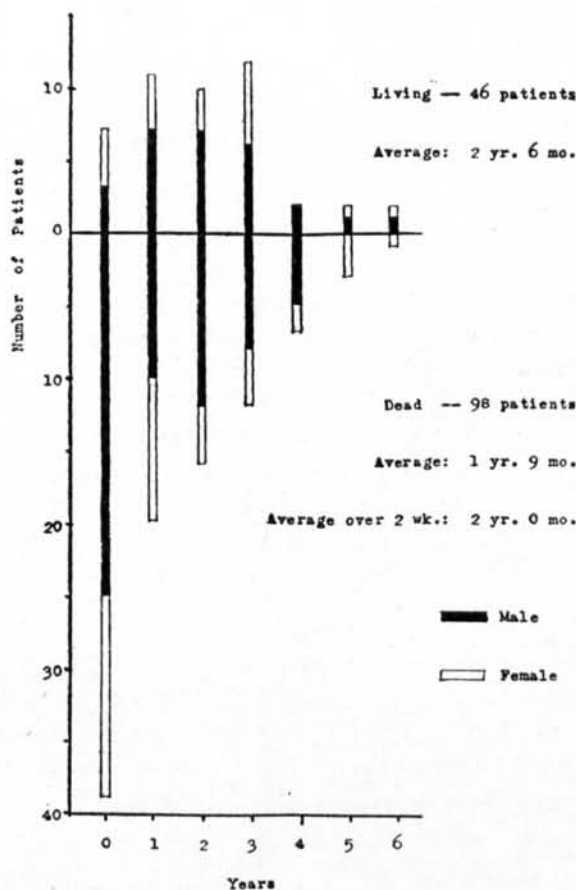


FIG. 6. Post-operative survival time for living and dead patients, by sex.

All of us hope that the near future will provide a chemo-therapeutic agent effective in leprosy, of sufficiently low toxicity for mass use. Until that happy day we must treat our patients symptomatically; and, as treatment of non-leprous conditions improves (as by use of sulfonamides and penicillin), we may expect patients to live longer—and the proportion of "tube cases" will increase.

XV. CONCLUSIONS

Experience at Kalaupapa Settlement with patients requiring tracheotomy has led to the following conclusions:

1. Most lepromatous patients who live long enough develop laryngeal stenosis in time and require tracheotomy.
2. It is not good practice to wait until an emergency arises. When indications are definite the operation should be performed, with careful attention to detail, especially control of bleeding.
3. Avoidance of meddlesome interference is the most important item in post-operative care.
4. "Chronic bronchitis" will eventually develop in tube-wearing patients, in time causing the death of those who have not succumbed to inter-current disease. This may be a few months after operation, or it may be more than 7 years.

XVI. SUMMARY

A group of 144 patients, of whom 46 are living and 98 have died, furnish clinical material for a study of tracheotomy in leprosy. Indications for operation, surgical anatomy, operative technic, and post-operative care are particularly emphasized.