The Role of Bronchoscopy in Tuberculosis of Infancy and Childhood*

HENRY J. RUBIN, M.D.¹
Beverly Hills, California

and

MARVIN S. HARRIS, M.D., F.C.C.P.²
Los Angeles, California

Although the use of the bronchoscope in tuberculosis among children has been the subject of a number of communications in recent years, the exact role of this procedure has not been defined. Especially is this true since the advent of antibiotics and chemotherapeutic agents. The present report is offered not as a reduplication of work which has gone before but to emphasize the value of continued exploration and a new approach to a situation which already has received attention.

Infants and children in this series were selected at random with the sole pre-requisite that they have active tuberculosis, diagnosed on a strongly presumptive or bacteriologically proved clinical status. The employment of bronchoscopy beyond this consideration was essentially at random and without regard for the usual criteria of endobronchial disease such as atelectasis, lobar or segmental distribution, wheeze, cough, or bacteriologic findings.

The series consisted of 37 children on whom 79 bronchoscopies were performed by one of us (HJR). These patients were chosen as indicated from a total group of approximately 80 children seen with tuberculous endothoracic disease at the Los Angeles County General Hospital from September, 1951, to December, 1953.

Technique

After a few initial frustrating bronchoscopies with no anesthesia, all children subsequently were examined under general anesthesia. We are in strong agreement with others¹ ² that there is no substitute for complete relaxation in these children, and this is assured by general anesthesia. Without such relaxation it is impossible to inspect each segmental orifice in a child because of violent expulsive efforts associated with struggling and coughing. The bronchus collapses over the mouth of the tube, and not more than a hasty unsatisfactory glimpse on inspiration is possible. Without anesthesia there is the additional hazard of traumatizing mucus

¹. Attending Bronchoscopist.
². Senior Attending, Medical Chest Service.

*From the Medical Chest Service, the Los Angeles County General Hospital. Presented at the Annual Meeting, California Chapter, American College of Chest Physicians, Los Angeles, California, May 8, 1954.
membrane, thereby favoring the initiation or extension of endobronchial disease.

Rectal barbiturates\textsuperscript{2, 3} are reported to be excellent, but in our hands open drop ether has proved equally satisfactory. Return of consciousness is rapid and the period of immediate postoperative observation by trained personnel shorter. Vinethene induction is followed by ether, and anesthesia is carried down to the second plane of the third stage. The anesthetist steps aside and the bronchoscope is introduced. It is unnecessary to insufflate ether through the bronchoscope because children remain without a significant cough reflex sufficiently long to permit unhurried examination and the taking of specimens. Upon withdrawal of the bronchoscope there is no laryngospasm. A mouth airway is inserted, the child is turned prone, and general management is the same as that following anesthesia for adenotonsillectomy. Recovery is rapid. This form of anesthesia is well tolerated, and there has been no evidence of aggravation of the pulmonary disease.

Postbronchoscopic subglottic edema has not been encountered because instrumentation is gentle and the bronchoscopes of proper size. Selection of the correct bronchoscope is most important. Generally speaking it is better in this type of examination to use a bronchoscope slightly smaller than that recommended for a given age. For example, a foreign body in a main stem bronchus of a 20-month-old infant can best be visualized and grasped through a 4-mm. bronchoscope. However, a 3½-mm. bronchoscope would be more suitable for examination of a tuberculous child because it better exposes the orifices of the segmental divisions of the lower lobes. The smaller bronchoscope can be insinuated farther and hence more can be seen. Particularly in the presence of any narrowing of the lumen of a main stem bronchus by disease the smaller bronchoscope superior. It is not sufficient to inspect only the trachea and main bronchi. All orifices, including the primary segmental ones, can and should be inspected individually.

Results

As indicated, the patients were selected essentially at random and were subsequently classified as bronchoscopically positive or bronchoscopically negative. Positive findings were limited to the presence of visible granulations, marked compression by external pressure, and severe orificial inflammatory stenosis. Redness of the mucosa and/or presence of purulent secretions were not considered evidence of specific disease and, although undoubtedly related to the underlying tuberculosis, were classified as not showing specific pathology.

The positive group consisted of 12 patients; seven of these had endobronchial granulomas, four had marked stenosis from external pressure, and one had severe inflammatory stenosis of the right middle lobe orifice. Of these 12 the average age was 33 months; six were 12 months or younger; the oldest was 48 months. Six were Negroes, three Latin Americans, two Caucasians, and one Oriental. Six (50 per cent) had positive identified con-
tact history with open tuberculosis, usually in the immediate family. Six (50 per cent) had positive gastric cultures. Only 25 per cent of the known contact cases proved to be bacteriologically positive. In addition to the six who were positive by gastric culture, two yielded positive cultures on bronchoscopic aspiration. Four (33 per cent) had persistent cough to suggest endobronchial disease. No frank sign of endobronchial disease was recorded in the ward officer's examination.

On x-ray film inspection, four had atelectasis of all or part of the right lower or middle lobe to suggest the presence of endobronchial disease. On the other hand, eight had merely confluent infiltrations or mass-like lesions which could not satisfy the criteria of atelectatic processes. Three of these were in the left upper, three in the right middle, one in the right upper, and one in the right lower lobes.

Comparing this positive group with the bronchoscopically negative there is little significant difference. The average age was 29 months and eight (34 per cent) 12 months or younger. Eleven were Negroes, seven Latin Americans, and seven Caucasians. Twelve (48 per cent) had positive history of contact, usually in the immediate family and these made up 66 per cent of the 12 who were bacteriologically positive on gastric culture. Cough of important severity or persistence was present in 25 per cent. No marked physical finding was recorded. X-ray studies disclosed shadows that satisfied criteria for atelectasis of a lobe or segment in eight patients. Six of these were in the upper lobes. Confluent infiltrative or mass-like shadows were seen in 13, calcifying hilar nodes in one, and unilateral emphysema and pleural effusion in one each.

In general, neither the historical, racial, nor bacteriologic findings seemed to distinguish the bronchoscopically positive and negative groups. Likewise the physical findings, symptoms, and x-ray shadows while generally recommended as a basis for distinction, did not seem to offer a means of differentiating between the two groups.

The bronchoscopic findings in the 12 bronchoscopically positive cases are summarized as follows:

Case 1: Age two years. The carina was greatly broadened, reducing the origins of both main stem bronchi to slits. As the bronchoscope was advanced, the medial walls of both main bronchi yielded easily to pressure. All of the usual orifices were identified and were clear. As the bronchoscope was withdrawn, the origins of the main bronchi again assumed their slit-like appearance. There was no endobronchial disease, the deformity being due to soft, enlarged mediastinal lymph nodes. (This child had a severe wheeze and stertorous respirations that could be heard down the hall.) Five weeks later all evidence of disease had cleared, and the carina had resumed its normal appearance.

Case 2: Age six months. The carina was broad. The bronchoscope was advanced on the right and no abnormalities noted. On the left the main stem bronchus was narrowed, and about ½ cm. below the carina a large amount of pus suddenly welled up and obscured vision. Repeated aspiration was followed by reappearance of pus until finally visibility was restored. The main stem bronchus was now much more patent, and pus was seen to be escaping in a constant trickle from a pin-point opening on the medial wall of the bronchus 1 cm. below the carina. The remainder of the bronchus and its orifices were clear. This of course represented a suppurating mediastinal lymph node which was pointing, and pressure of the bronchoscope caused rupture into the main bronchus.

On re-examination three weeks later the left main stem bronchus was of normal patency. At the site of perforation a small nubbin of pale inactive looking granulation
tissue was present which was not disturbed. There was no pus. On final examination seven weeks after the initial one the tracheobronchial tree appeared normal.

**Case 3:** Age six months. The carina was broadened, the fullness extending down the right main stem. At the level of the middle lobe orifice the main bronchus was reduced to a slit, the medial wall almost contacting the lateral. At this point the mucous membrane was granular, bled easily, and was studded with flecks of exudate which could not be detached with suction. Bronchoscopy two months later showed no change. Final examination seven months after the first showed complete resolution of disease. The stenosis here was principally the result of deformity by extrinsic pressure rather than by endobronchitis.

**Case 4:** Age eight years. Just below the level of the right upper lobe orifice the main stem bronchus was occluded by a soft, easily bleeding granuloma. A suction tip was forced past it and at once aspirated in a steady stream over a half ounce of heavy green pus which had been trapped behind the granuloma. This was partially removed with forceps, bleeding obscuring the field. Two weeks later the granuloma previously noted was seen to arise from the medial wall of the main stem bronchus. It was forced aside, and the bronchoscope advanced to the base. A large amount of pus was again aspirated. The lower segmental orifices were identified and free of disease. The surface of the granuloma was rubbery and could not be grasped so that only a small piece could be removed.

One month after the initial bronchoscopy there was complete resolution of active disease, and the nature of the previous observations became clear. From just below the middle lobe orifice to the base the main stem was severely distorted by fullness of the medial wall due to extrinsic pressure. What previously appeared to be entirely granuloma was only partially so, much of it representing underlying bronchial wall which had been pushed medially by diseased mediastinal lymph nodes. The mucous membrane had completely healed, but the bronchus was narrowed. The child was discharged home and not bronchoscooped again as permission was refused. Judging from observations on other children, the bronchus may be expected to regain its normal caliber.

**Case 5:** Age four years. The mucus membrane of the right main stem bronchus was injected as compared with the left, and pus escaped from the upper lobe. Granulation tissue, which bled on touch, covered the spur of the right upper lobe bronchus. The orifice itself did not appear to be obstructed by disease. Examination three months later revealed no evidence of disease.

**Case 6:** Age four years. Just below the right upper lobe orifice the main bronchus was filled by a large, soft, easily bleeding granuloma. This was grasped with fenestrated mosquito forceps and removed piece meal. The middle lobe orifice was then visualized and seen to be patent. The granuloma arose from the most medial portion of the middle lobe bronchus and the adjacent main bronchial wall. Two weeks later the granuloma was smaller, paler, and flapped back and forth on respiration. It was again removed. On final examination six weeks after the first, all evidence of endobronchial disease had disappeared.

**Case 7:** Age 18 months. The middle lobe orifice was inflamed and so edematous that its lumen was reduced at least 50 per cent. Pus escaped on cough. Six weeks later all edema had subsided and the orifice was widely patent.

**Case 8:** Age two years. The right middle lobe orifice was thickened by infiltrative changes and acutely inflamed. On tilting the bronchoscope to afford better exposure a large plug of heavy inappasated solid debris popped out and was removed. This had completely obstructed the bronchus. A thin mucopurulent secretion then escaped. The lower lobe spurs were thickened and glossy but not specifically diseased. On repeated bronchoscopies the inflammatory changes involving the middle lobe orifice subsided, but it was completely filled by a granuloma which could not be removed and around which thin pus escaped. On final examination five and one half months later the granuloma still filled the lumen.

**Case 9:** Age two years. The right main bronchus was acutely inflamed and filled with thick green exudate so adherent and tenacious as to suggest a membrane. The bronchus was cleared with suction, and pus was seen to be escaping on cough from the middle lobe orifice. The orifice itself was inflamed and edematous almost to the point of occlusion. On aspiration two weeks later there was no significant change, but on subsequent bronchoscopies there was gradual improvement. For months the main stem was thickened, granular, bled easily, and nubbins of granulation tissue were scalped off. On final examination seven months after the initial bronchoscopy there was no evidence of disease, and the middle lobe orifice was widely patent. (Rapid improvement followed the administration of rimifon.)

**Case 10:** Age two and one half years. Just below the right upper lobe orifice the main stem bronchus was occluded by caseous exudate and granular thickening. The
bronchoscope was forcibly advanced and this inspissated debris aspirated. Immediately a large quantity of fluid pus escaped from below. No individual landmarks could be recognized at this time. Two weeks later there was marked improvement, exudate no longer obstructing the bronchus and a suction tip aspirating no pus. The entire mucosal surface was granular, and the lumen much narrowed. Four months later all evidence of active endobronchitis had subsided, but the right main stem from just below the upper lobe orifice was narrowed about 50 per cent as compared with the left. The child was discharged clinically free of active disease but with an apparent residual bronchial stenosis.

He was again bronchosoped 16 months after discharge from the hospital, and both main stem bronchi were of the same caliber throughout their entire lengths. The middle lobe orifice, which had never been previously visualized, was easily identified and appeared normal, as did the basal segmental orifices. That portion of the tracheobronchial tree capable of being inspected through a bronchoscope had returned to normal.

Case 11: Age three and one half years. The orifice of the left upper lobe was acutely inflamed, edematous, and bled on touch. A small granuloma partially filled the lumen. This was removed with forceps. Three weeks later all evidence of acute inflammation had subsided. A small granuloma was again present in the orifice and was removed. On final examination five months after the first one there was complete resolution of all disease, and the left upper lobe orifice was widely patent.

Case 12: Age two years. The left upper lobe orifice was inflamed and granular practically to the point of occlusion. Membranous exudate was so thick that it blocked the suction tip and had to be picked off its end. The inspissated secretion was acting as a foreign body. One month later all inflammation and exudate about the orifice had cleared, but the lumen was completely occluded by a soft granuloma which protruded slightly into the main stem lumen. Bronchoscopy was repeated on several occasions and that portion of the granuloma extending into the main stem scalped off. All active inflammation had subsided, but the lumen was completely filled by granuloma. (On x-ray film inspection the entire left upper lobe showed gradually increasing contractive changes; the child recovered clinically.)

Discussion

Consideration of the problem in the light of these findings and those who have reported before us poses two questions. Does bronchoscopy provide information that cannot be obtained otherwise, and is the information so obtained of essential importance to prognosis and therapy? The answer to both questions seems to be in the affirmative.

From our experience the existence of an atelectatic shadow will probably lead to the discovery of endobronchial disease provided the orifices to that segment or segments are accessible to the bronchoscope. Where such accessibility is not easy, as in the upper lobes and to a lesser extent in the middle lobe, it is likely that endobronchial granulations often exist beyond the scope of vision. It is therefore possible that the eight patients with atelectatic shadows in our bronchoscopically negative group simply had such lesions which could not be seen. But what is of greater significance is that eight cases showed bronchoscopic evidence of disease which could not have been predicted on the basis of clinical or x-ray data.

The frequent sequel of bronchielectatic disease as an aftermath of tuberculosis emphasizes the importance of securing early and lasting relief from such lesions. Not only do the granulations represent excrescences on the bronchial sometimes harboring tuberculous organisms, but they replace normal mucous membrane and act as nonspecific foreign bodies. Secretions distal to them cannot drain, thus setting in motion the train of events leading to atelectasis and ultimate bronchielectasis. The importance of removing them and aspirating inspissated secretion and trapped
pus cannot be overemphasized. If the mucosa is merely inflamed and granular, it will return to normal as the underlying pulmonary disease is brought under control, but formed granulomata require a more definitive approach.

The fate of this insidious endobronchial disease cannot be tied to the fate of the underlying tuberculosis and left to the beneficial effects of the antibiotics and chemotherapeutic agents. Our experience, and that of others, points to the necessity of a two-fold attack: antibiotics and chemotherapeutic agents for the underlying disease, and the endoscopic removal, as often as they recur, of endobronchial granulations.

An unsolved problem lies in the management of those granulomata beyond the reach of forceps. In several children the adjacent main stem bronchus was free of disease but obstructing granulations remained tantalizingly out of reach in the left upper or right middle lobe orifices. Herein lies the outstanding shortcoming of bronchoscopy. The segmental orifices cannot be reached and granulations at these levels cannot be removed. This may explain those instances in which the main bronchi are restored to gross normalcy, but the x-ray picture shows little or no change.

The basis of these granulations is not completely apparent. Gorgenyi believes they form at or adjacent to the site of rupture of caseous mediastinal or peri-bronchial nodes and extend along the bronchial wall. The fact that they are most commonly seen on the mesial wall of the main bronchus or the mesial lips of the secondary orifices may lend some weight to this concept. Hardy et al. described one patient where granulations developed at the point of rupture, and we have witnessed the development of one such granulation after observing initially the appearance of only a pin-point rupture into the left main bronchus (Case 2).

General Course of the Disease

All the patients in the negative and positive groups were on a course of antibiotic therapy during the period of observation. As a general rule the children under four received $\frac{1}{4}$ gram of streptomycin intramuscularly twice weekly, supplemented by 4 grams of PAS daily in a flavored freshly prepared oral solution. The older or larger children received .35 to .5 grams of streptomycin and 6 grams of PAS. In the event of continued fever or evidence of dissemination of the streptomycin dosage was increased temporarily to daily frequency, but rarely was the dose made larger. Children on this drug regimen with obstructive endobronchial granulomata did not show satisfactory clinical improvement until the granulations were removed and retained pus aspirated. In a few instances INH was added when progress was not as anticipated. Under this combined regimen the progress of all children observed was satisfactory and to date no disseminations in the form of miliary or metastatic disease to the meninges or other extra-pulmonary sites has occurred.

Since the fate of stenosis by pressure and inflammatory orificial stenosis is dependent on the outcome of the underlying disease, it would appear
that the continued use of these antituberculosis agents is indicated where such endobronchial evidence of disease is demonstrated.

Since this report was prepared, INH has been included in all chemotherapy. We gratefully acknowledge the cooperation of the Department of Anesthesia.

CONCLUSIONS

1. A series of 79 bronchoscopies on 37 children with pulmonary tuberculosis is reported.
2. The children were selected at random, without particular regard for the usual criteria for bronchoscopy.
3. Twelve (32.4 per cent) had visible endobronchial disease. In seven this was manifested by granulomata, in four by deformities resulting from the pressure of enlarged mediastinal lymph nodes, and in one by inflammatory orificial stenosis.
4. Drugs alone brought about resolution of enlarged nodes and granular mucous membrane but not of formed granulomata.
5. Bronchoscopic removal of granulomata and aspiration of exudate was effective in restoring to normal appearance those bronchi visibly involved by granulomatous disease.
6. Both the x-ray and clinical signs are unreliable in determining prior to bronchoscopy which child will have visible endobronchial disease.
7. Bronchoscopy is an important adjunct in the diagnoses and treatment of children with pulmonary tuberculosis and should be performed on those in whom the total picture indicates the necessity of more than merely casual observation.

CONCLUSIONES

1. Se reporta una serie de 79 broncoscopías en 37 niños con tuberculosis pulmonar.
2. Los pacientes fueron seleccionados al azar sin atender particularmente al criterio usual de indicación broncoscópica.
3. Doce (32.4%) tuvieron enfermedad visible endobronchial. En siete se manifestaba por granulomas, en cuatro por deformidades resultantes de la presión ejercida por ganglios linfáticos mediastínicos crecidos, y en uno por estenosis inflamatoria orificial.
4. Con sólo medicinas se resolvieron los casos de ganglios crecidos y los de membranas mucosas granulosas, pero no los de granulomas ya formados.
5. La extracción broncoscópica de las granulomas y la aspiración del exudado, fueron efectivos en restaurar la apariencia normal de aquellos bronquios visiblemente invadidos por enfermedad granulomatosa.
6. Previamente a la broncoscopy, ni los rayos X, ni los signos clínicos, son datos de confiar en la determinación de cuales niños tendrán enfermedad endobronquica visible.
7. La broncoscopy es una ayuda importante en el diagnóstico y tratamiento de niños con tuberculosis pulmonar, y debe hacerse en aquellos en quienes el cuadro clínico indica la necesidad de una observación más que meramente casual.
Vol. XXVIII  BRONCHOSCOPY IN TUBERCULOSIS  195

RESUME

1. Les auteurs rapportent une série de 79 bronchoscopies pratiquées sur 37 enfants. Les enfants furent choisis au hasard sans tenir compte des critères habituels qui font décider une bronchoscopie.

2. Douze d'entre eux (32,4%) étaient atteint de lésions endobronchiques visibles. Chez sept, il s'agissait de granulomatose, chez quatre, de déformation due à la compression par des ganglions médiastinaux augmentés de volume et chez un d'entre eux par une sténose orificielle inflammatoire.

3. Par de simples médications, on obtint une résolution des adénopathies médiastinales, et des lésions des muqueuses, mais il n'y eut aucune action sur le granulome constitué.

4. Sa suppression par voie bronchoscopique associée à l'aspiration de l'exsudat, permit de rendre une apparence normal aux bronches, qui étaient de toute évidence atteintes par la maladie granulomateuse.

5. Il était impossible de déterminer, soit par l'examen radiologique, soit par l'examen clinique, quel enfant était atteint d'une affection endobronchique. Ce n'est que la bronchoscopie qui le permet.

6. La bronchoscopie est un auxiliaire important dans le diagnostic et le traitement des enfants atteints de tuberculose pulmonaire. On doit y avoir recours chez tous ceux dont le tableau d'ensemble en indique la nécessité, et non pas dans quelques cas isolés.

REFERENCES