A Method for Topical Anesthesia by Nebulization of Local Anesthetics

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The number of procedures involving the direct examination of, and the introduction of instruments and materials into, the tubular structures of the respiratory tract is increasing. This increase in endoscopic procedures has been attended by greater efforts to overcome the natural defenses of the entrance to the respiratory passages. The defenses are:1

1) The swallowing reflex, originating chiefly in the posterior pharynx, dorsum of the tongue, and pyriform sinuses.

2) The gag reflex, originating chiefly in the anterior faucial pillars, soft palate, uvula, epiglottis, and posterior pharynx.

3) The cough reflex, originating chiefly in the larynx, trachea, and carina.

4) The anatomic position and structure of the larynx, at right angles with the oral cavity, below the epiglottis, and with the strongly contractile glottis at its entrance.

5) The patient's general apprehension concerning instrumentation of the respiratory passages.

The most commonly practiced method of reducing the patient's apprehension is by preliminary sedation and a brief explanation of the necessity for relaxation and cooperation. The reflex defenses are usually attacked by administering a surface anesthetic. The anatomic peculiarities of the larynx constitute a major difficulty in introducing anesthetic solutions as well as instruments and other materials.

The conventional technique of obtaining surface anesthesia consists of "boldly squirting 2 or 3 cubic centimeters from a syringe (or atomizer) through the mouth on to the posterior pharyngeal wall; after which the anesthetist side-steps smartly out of the line of the patient's mouth and relies on the violent gagging and coughing to spread the liquid throughout the pharynx and larynx."2 It is usually necessary, in addition, to swab the

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anterior pillars and pyriform sinuses with cotton pledgets soaked in the anesthetic solution, and finally to inject more of the solution into the larynx through a curved tracheal cannula under laryngoscopy. The anesthesia which results is often inadequate for bronchoscopy, necessitating the application of additional solution directly onto the carina through the bronchoscope.

The disadvantages of this technique are apparent. It requires an excessive quantity of the drug, several specialized instruments, and a technically skilled operator. It is distasteful to the patient and time-consuming to the physician. Consequently there has been a concerted attempt to develop a technique which secures adequate and widespread anesthesia without these disadvantages.

Perhaps the most precise modification of the conventional method is that described for laryngoscopy by Jackson, who atomizes the pharynx and right faucial pillar for one or two seconds with 10 per cent cocaine. He then introduces three or four drops of the solution into the larynx under mirror visualization, and after 3 minutes repeats this amount. Jackson states that it is essential that every drop from the syringe be seen to enter the larynx in order to obtain adequate anesthesia from such a small amount of solution. For bronchoscopy, he mentions the additional application of a small quantity of 4 per cent cocaine through the bronchoscope. While the amount of solution employed in his procedure is small, all the other disadvantages are still present. The accurate placement of each drop of solution depends on a dexterity that few operators possess.

Another modification using small dosage has been described recently by Carabelli who employs 0.25 per cent pontocaine. He uses a total of 8 cc. of solution, first spraying into the pharynx through a micro-atomizer, then instilling the balance into the trachea through an endotracheal catheter. Its chief advantage is that it is one of the few techniques in the literature that does not exceed the recommended dose of the drug. Its main disadvantage is that it involves introducing an endotracheal catheter. Furthermore, our work with fine particle atomizers disclosed that the disadvantages inherent in the use of ordinary atomizers were not completely overcome.

The disadvantages encountered in spraying via the mouth led to an investigation of the nasal route. Adams, Slater, and Carr and his associates, have described techniques of instilling the anesthetic solution through a nostril while the tongue is held to prevent swallowing. When the solution reaches the glottis, coughing occurs; continued administration followed by further coughing finally results in anesthesia which is adequate for injecting iodized oil through the same nostril for passive bronchography. The use
of this technique reduces but does not eliminate the patient's discomfort; it may be used for bronchography, but is not applicable to endoscopic procedures.

A technique described by MacIntosh\textsuperscript{2} utilizes a rubber nasal catheter with an atomizer tip. The catheter is used to direct the atomized cocaine into the nasal and pharyngeal passages, being gradually advanced through the nasopharynx as anesthesia is obtained, and finally passed into the larynx for endotracheal anesthetization. He states that a cough is a sure sign that the spray has found its target. Thus the technique involves discomfort to the patient, and requires skillful manipulation to pass the catheter into the larynx. Rowbotham,\textsuperscript{8} Kenton,\textsuperscript{9} and Harang\textsuperscript{10} have each designed different instruments or procedures which are subject to the same disadvantages as those described.

Still another route of administration has been employed by Armand-Delille,\textsuperscript{11} Guy and Elder,\textsuperscript{12} and Grady.\textsuperscript{13} They insert a cannula through the skin of the neck and the cricothyroid membrane directly into the larynx after local infiltration of these tissues with 0.5 per cent procaine. A topical anesthetic is then injected through the cannula, producing a paroxysm of coughing which serves to spread the agent throughout the area to be anesthetized. Iodized oil may then be injected through the same cannula to obtain bronchograms. This has been described as an excellent technique for bronchography in small children, but seems somewhat radical in approach with potentially grave complications.

The technique designed and originally described by us\textsuperscript{14} is based on nebulization of the surface anesthetic solution. By having the patient inhale the mist under certain conditions, a profound surface anesthesia is obtained which extends from the external nares and mouth to the finest bronchioles. Other authors\textsuperscript{2,15,16} have noted the logic of the use of nebulizers in obtaining surface anesthesia, but have not described a detailed technique or a tabulation of results.

It is important to distinguish nebulization from atomization. Ordinary atomization is the production of a spray of relatively large droplets travelling at high speed. When this spray strikes the sensitive areas of the pharynx which must be reached to obtain adequate anesthesia, it usually results in gagging, retching, and coughing, as previously pointed out. In nebulization the largest droplets are baffled out within the nebulizer, resulting in a fine mist of particles that may be inhaled comfortably and carried by convection into the deeper bronchial passages.\textsuperscript{17} This method overcomes all the defenses of the respiratory system, without the disadvantages of the conventional method of anesthesia or its modifications.
Materials

The essential instrument is an adequate nebulizer. We have found some nebulizers to be inadequate. The following properties of the nebulizer are desirable:

1) Efficiency of nebulization: The delivery of aerosol by the nebulizer must be sufficiently rapid. Many nebulizers are inefficient, i.e., the amount of liquid delivered per unit volume of gas passing through the nebulizer is low, and adequate anesthesia is difficult to establish.

2) Construction of the nebulizer: The well of the nebulizer must be capacious enough to accommodate 8 cubic centimeters of solution. It must also be so constructed that tilting the nebulizer does not easily spill the solution out of the neck of the nebulizer into the patient's mouth, since rapid absorption of surface anesthetics may result in toxic reactions.

3) Particle size distribution: The aerosol produced by the nebulizer must consist of particles which are below the size range that produces reflex gagging, and yet not so small that they remain suspended and are exhaled (approximately 0.5 micron and smaller). The ideal particle size range for surface anesthesia is 0.5 to possibly 5 micron in radius. Within this range, the majority of particles should be small enough (0.5 to 2 micron) to be carried by convection and deposited in the bronchial tree. A substantial amount of the aerosol, however, should consist of intermediate sized particles (2 to 5 micron) that will be deposited by centrifugal force in the pharynx and larynx.

Some nebulizers produce too high a percentage of larger droplets that are unable to traverse the pharyngo-laryngeal angle without deposition on the posterior pharynx, and hence fail adequately to anesthetize the bronchial tree. These nebulizers are little better than atomizers in their final results. Other nebulizers produce an aerosol consisting almost entirely of particles so small that they uniformly reach the bronchial tree, but fail to anesthetize the pharynx and larynx adequately through lack of sufficient particles of intermediate size.

This phenomenon has been studied exhaustively by nebulizing known quantities of PSP from various nebulizers, to the delivery ends of which are attached right-angle L tubes. The amount of PSP remaining in the nebulizer and the amount deposited in the L tube after nebulizing under uniform conditions can be determined colorimetrically. From these figures can be calculated the per cent delivery of the nebulizer and the per cent deposition of intermediate sized particles in the L tube.\textsuperscript{18,19}

A nebulizer that fulfills the requirements for use in surface
anesthesia, both clinically and in laboratory studies of particle size distribution is the DeVilbiss No. 40. Intermediate sized particles comprise 15 to 20 per cent of the total delivery. This model was used for all cases herein reported.

Oxygen or air may be used to nebulize the solution. An oxygen tank with attached flow meter, or an air compressor will suffice. Oxygen was used routinely for these cases because of its availability and convenience. The pressure was transmitted to the nebulizer through ordinary gum rubber tubing.

A simple mouthpiece for the nebulizer consists of a segment of rubber tubing three inches long and one-half inch in diameter (Fig. 1). It is pushed about one inch onto the oral end of the nebulizer so that the point of delivery of the aerosol is extended about two inches into the mouth. This is an important step in procedure as it prevents the patient from unwittingly baffling out much of the aerosol by partially occluding the mouth of the nebulizer with the teeth or tip of the tongue.

In performance of bronchography, lipiodol is often instilled through the nose and allowed to flow passively into the bronchial tree. In such cases, nasal tips* may be attached to the

*The nasal tips and the nebulizer are included in the DeVilbiss No. 640 combination.

FIGURE 1: DeVilbiss No. 40 nebulizer with rubber mouthpiece.
nebulizer and the first half of the anesthetic solution inhaled through the nose to insure anesthesia of the nasal and nasopharyngeal mucosa.

The anesthetic solutions preferred are 0.5 per cent pontocaine and 4 per cent cocaine. After extensive experimentation it was found that stronger solutions were unnecessary, and weaker ones inadequate. One minim of epinephrine 1:1000 is added for each cubic centimeter of solution to delay absorption. When cyclopropane anesthesia is to follow, the epinephrine is omitted to prevent a possible cumulative irritation of the cardiac musculature.

The only other materials employed are those necessary for maintaining proper precautions whenever surface anesthetics are used, viz. sodium pentothal, epinephrine, a suction machine, and apparatus for administering oxygen and artificial respiration.

**Premedication**

Our patients are usually premedicated with nembutal two hours before, and morphine and atropine one hour before anesthetization. The dosage may be varied to suit the individual patient or the preference of the physician, and substitutions such as demerol, codeine, scopolamine, etc., are perfectly compatible with good results. However, either atropine or scopolamine should always be employed, as copious secretions tend to dilute the anesthetic agent, and the concentration of these agents is already minimal. The premedication serves the purpose of sedating the patient, minimizing apprehension, inhibiting secretions, and combating the side reactions of the anesthetic agent.

**Method**

The patient is seated, his nose is occluded by adhesive tape, and he is instructed to relax and simply breathe through his mouth. Eight cubic centimeters of anesthetic solution are introduced into the nebulizer and the oxygen flowmeter adjusted to approximately 6 to 8 liters per minute for continuous nebulization. Generation of aerosol continuously is more wasteful than generation only during inspiration, but it allows the use of a single technique on patients of all ages and degrees of ability manually to operate a Y tube.

The production of aerosol is demonstrated to the patient, and it is explained that he is to inhale the mist. The nebulizer is inserted into the patient's mouth in such a way that the delivery end of the rubber mouthpiece is well into the back of the mouth. As the patient is inhaling the aerosol, he is prepared for the sensations of surface anesthesia by explaining that soon his tongue will become numb, he will feel a "lump" in his throat, and he
will finally be unable to swallow. He is then instructed in the proper method of holding the nebulizer and he continues to do so for 30 minutes.

During the first five minutes the tip is allowed to point straight back toward the uvula. Then the anterior faucial pillars are anesthetized by turning the nebulizer 30 degrees for five minutes to each side in turn. For the second 15 minute period, the patient holds his own tongue forward with a gauze sponge, introduces the nebulizer tip as far back as possible, and aims toward the larynx and the pyriform sinuses for five minutes each. The entire procedure requires 30 minutes. In this way, the aerosol reaches not only the deeper bronchial structures by convection, but also the sensitive areas of the pharynx and larynx by direct impact.

After the preliminary instruction, the patient continues his own anesthetization without fear or apprehension, and immediately at the end of nebulization is ready for the endotracheal or endobronchial procedure. The entire technique requires about five minutes of the anesthetist's time. The anesthetist therefore, is free to do other work in the 25 minutes remaining while the patient administers his own anesthetic under supervision.

**Modifications of Technique**

1) For recumbent patients: Our experience with surgical patients has been predominantly with cases requiring endotracheal intubation for the administration of general anesthetics. It is generally agreed that topical anesthesia is preferable or is a

**FIGURE 2A**

*Fig. 2A:* Bronchogram of a 5 year old child with bronchiectasis of the right upper lobe.—**FIGURE 2B**: Bronchogram of a 10 year old child with bronchiectasis of the right middle lobe.
desirable supplement to general anesthesia for the introduction 
of the endotracheal tube. Since the patients are routinely wheeled 
into the hall or foyer of the operating room on stretchers to await 
their turn on the operating table, a convenient place and time 
for administration are available. The nose is taped off and the 
patient's head rotated to one side and the mouthpiece introduced 
by an assistant as described above. Because of the sedation and 
reclining posture, the patients often doze throughout the procedure.

2) For small children: Children above the age of four or five 
years use the same techniques as described for adults. For younger 
children, the entire procedure is carried out with the child sitting 
on the lap of a nurse, who cuddles the child in one arm and places 
the straight rubber tip of the nebulizer in the child’s mouth as 
though administering a bottle feeding. The younger child has a 
feeling of security when handled in this way, and the elements 
of fear and apprehension are almost completely absent. The use 
of nebulization anesthesia was originally conceived for the pur-
pose of obtaining bronchograms in children with chronic pul-
monary diseases and our experiences with this method have been 
gratifying (Fig. 2).

Results

The procedures performed with this technique include broncho-
graphy, bronchoscopy, bronchspirometry and endotracheal intu-
bation. In order to have all participating physicians evaluate cases 
uniformly, four degrees of response were formulated. An excellent

![Figure 2c](image1)  ![Figure 2d](image2)

**FIGURE 2C**  **FIGURE 2D**

Bronchograms of an adult, demonstrating the entire bronchial tree, with fill-
ing of what is probably an epithelialized tuberculous cavity.
result was considered one in which there was absolutely no gag or cough during the entire endotracheal or endobronchial procedure, a condition that is infrequently obtained by conventional methods. For bronchoscopy this classification had to be slightly modified as it was observed that an occasional patient emitted a single mild coughing effort when the bronchoscope reached the carina. A good result was one in which there was slight gagging or coughing which immediately subsided and did not interfere with the endoscopic procedure. A fair result was defined as one in which there was occasional repeated gagging or coughing. A poor result was one in which marked gagging and coughing occurred throughout the procedure. The vast majority of results fell into the classification of excellent, and the balance were good. There were no fair or poor results recorded by any of the operators, when using the technique exactly as described.

This is apparently the simplest technique devised for obtaining surface anesthesia of the entire respiratory passage. It requires no operative skill or manipulative ability, and no expensive or specialized instruments. All the materials are standard hospital equipment except the nebulizer, which is available at almost any pharmacy. A profound and evenly distributed anesthesia is obtained throughout the lower as well as the upper respiratory tract with no discomfort to the patient. The anesthesia is always as good as that obtained by conventional methods and in most cases better.

The time required of the anesthetist is less than in other methods, as the patient administers the greater part of the anesthetic to himself. Even when the patient is necessarily recumbent, the modified technique allows the anesthetist to circulate in the close vicinity of the patient while an assistant trained in the signs of toxicity holds the nebulizer and stands watch by the stretcher.

Aside from the medical and technical aspects, one of the greatest advantages is the absence of discomfort to the patient. There is no gagging, coughing, or spitting associated with its use. Finally the likelihood of toxic reactions is greatly diminished. The retention of various aerosols administered in the manner described has been reported by several authors to be of the order of 6 per cent, 15 per cent and 25 per cent. In attempting to evaluate per cent retention of aerosols when administered as described, one of us (J.B.M.) inhaled a solution of phenolsulphothalein, using the method of Abramson, and found that the total urinary excretion was 14.57 per cent after 16 hours. Even assuming that the retention is as much as 25 per cent of the 8 cubic centimeters, the actual amount absorbed is only 2 cubic centimeters. This is the equivalent of 0.5 cubic centimeters of 2 per cent pontocaine,
or 0.8 cubic centimeters of 10 per cent cocaine, well below the toxic dosages of these drugs. Furthermore, the absence of large drops and pools of solution in the pharynx and mouth, plus the drugs and anesthetics administered to prevent the accumulation of saliva and to abolish the swallowing reflex, completely eliminates swallowing the toxic solutions.

The chief criticism of the procedure is that it is time consuming. It is true that a cooperative patient can be anesthetized more rapidly by some of the other methods. However, perusal of medical writings reveals the fact that many authors recommend a period of 20 to 30 minutes to obtain satisfactory anesthesia, and that one of the most frequent causes of poor anesthesia is failure to take sufficient time to apply the solution and await its maximal action. In attempting to hasten the procedure, we have used stronger anesthetic solutions for shorter periods of time, and found that the anesthesia produced was not as widespread as that produced by using the recommended strengths for the full 30 minutes. This phenomenon is probably due to the small size of the particles produced by nebulizers, and the consequent slow surface coverage of the areas involved. This can be illustrated by aiming an atomizer spray and an aerosol of PSP toward filter papers that have been soaked in 10 per cent sodium hydroxide. Instead of reddening immediately as does the atomized paper, the nebulized paper gradually turns faintly pink and over a surprisingly long period of time finally becomes red.

There are apparently no dangers inherent in this method. The use of surface anesthetics always carries an element of risk and reactions may occur in children and hypersensitive patients even with the use of minute amounts of drugs. Only one such reaction has occurred in our series. Early in the study, while using 2 per cent pontocaine, a 1½ year old colored girl began convulsing while being anesthetized for bronchography. Fortunately, she responded to the administration of intravenous barbiturates and oxygen inhalation, and suffered no ill effects.

The limitations of this method for topical anesthesia by nebulization of local anesthetics are as yet indefinable. Its use has met with success in many procedures requiring surface anesthesia of a widespread distribution by gentle application. In addition to the endoscopic aspects of surface anesthesia, it has been used for temporary relief of sneezing, the pain of severe pharyngitis and laryngitis, and for intractable coughing in tracheitis, bronchitis, and pertussis.

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SUMMARY

1) The conventional methods of obtaining topical anesthesia of the respiratory passages entail difficulties for the physician and discomfort to the patient.

2) A method of administration of topical anesthetics by nebulization is described in detail.

3) Nebulization anesthesia has proved successful and satisfactory for bronchoscopy, bronchography, bronchospirometry, and endotracheal intubation.

4) The success of this method is based on the particle size of the aerosol produced by the nebulizer.

5) This method is almost entirely free from the disadvantages and dangers of the conventional methods, and is accompanied by little or no discomfort to the patient.

RESUMEN

1) Los métodos convencionales de producir anestesia tópica de las vías respiratorias causa dificultades al médico e incomodidad al enfermo.

2) Se describe detalladamente un método de administrar anestésicos tópicos mediante la pulverización.

3) La anestesia de pulverización ha dado resultados satisfactorios en la broncoscopia, broncografía, broncospirometría e intubación endotraqueal.

4) El buen éxito de este método depende del tamaño de las partículas del aerosol producidas por el pulverizador.

5) Está casi exento este método de las desventajas y riesgos de los métodos convencionales y causa poca o ninguna incomodidad al enfermo.

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