Surgery of the Upper Respiratory System

William W. Montgomery

Preface

This atlas of otolaryngologic surgery has been compiled for both the physician in training and the practicing specialist.

The past decade has seen otolaryngology expand to the point where many otolaryngologists have limited their surgery to one aspect of the specialty, such as otology, head and neck surgery, plastic procedures, or surgery of the paranasal sinuses. This trend, however, is only practicable in large medical centers that can be staffed by many specialists.

The modern otolaryngologist must be an accomplished surgeon, for a single operation can require the versatility and dexterity needed for handling soft tissues and bones, as well as various macro- and microsurgical procedures. The otolaryngologist must also be proficient in the diagnostic procedures associated with head and neck surgery and possess acumen in the interpretation of the results. He must have thorough knowledge of the anatomy and physiology of the upper respiratory system to enable him to deal effectively with diseases of the nose, paranasal sinuses, nasopharynx, oropharynx, laryngopharynx, cervical esophagus, and neck.

In this volume it has been my aim to provide the student and the practicing otolaryngologist with guidelines for the diagnosis and treatment of the various conditions requiring otolaryngologic surgery. To this end, covered in the volume are descriptions and illustrations pertaining to examination, diagnosis, and treatment of paranasal sinus disease, cerebrospinal fistula, facial fractures, and nasal and nasopharyngeal disorders. Because otologic operations have been dealt with extensively in a number of recently published textbooks, discussions on surgery of the ear have been limited to reconstructive surgery of the auricle, operations for acoustic neurinoma, in which I am particularly interested, and carcinoma of the ear. Although I have endeavored to present the latest techniques, with the rapid advancement in the field of otolaryngologic surgery it is possible that new diagnostic procedures and methods in treatment may evolve while this book is in press. Comments by the reader concerning these as well as any criticisms will be appreciated. By such means, progress is advanced and goals are attained.

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Mr. Johnson's interest in the needs of modern medicine, leading among other things to this present volume, is only one face of the personality of this "Tall Man." The author wishes to express his gratitude to him.

W. W. M.
Chapter 1: The Examination

Nose

History

Patients with disease of the nose or paranasal sinuses will complain of anterior nasal discharge, posterior nasal discharge, nasal stuffiness or obstruction, localized pain over a sinus, headache, bleeding, sneezing, and/or external swelling. The following inquiries should be made and the replies carefully recorded for each patient who comes to the physician for the first time with potential nasal or sinus disease.

1. When did the trouble start?
2. What was it like at that time?
3. How has it progressed until the present time?
4. Nasal discharge:
   a. Is it anterior or posterior?
   b. Is it unilateral or bilateral?
   c. Is it persistent or intermittent?
   d. Is the amount slight, moderate, or profuse?
   e. Is it purulent, watery, mucoid, or bloody in character?
   f. Does it have an odor or taste?
   g. Does it have an unusual color?
5. Sneezing:
   a. Amount?
   b. Frequency?
   c. During what time of the day?
   d. Is it accompanied by rhinorrhea and/or epiphora?
   e. Is it seasonal?
6. Nasal obstruction:
   a. Is the obstruction partial or complete?
   b. Is it unilateral or bilateral?
   c. Does it have any time-of-day relationship?
   d. Is it associated with environmental factors?
   e. Is it associated with the ingestion of liquids or food?
7. Olfactory system:
   a. Is there any distortion of smell?
   b. Is there partial or complete absence of smell?
   c. How long has the anosmia persisted?
   d. Is the anosmia associated with other signs or symptoms?
8. Pain:
   a. Does the pain consist of generalized headache, or is it localized to the distribution of the nose and paranasal sinuses? (Generalized headache is usually not a symptom of intranasal or sinus disease.)
   b. Is it true pain or a sensation of pressure?
   c. Is the pain associated with other symptoms, such as nasal blockage, rhinorrhea, or sneezing.

9. Has there been a history of redness or swelling in relation to the external nose and paranasal sinuses.
Local Examination

For examination of the nose, a head mirror, light source (100-watt bulb), and instrument tray containing a nasal speculum, finger cots, an atomizer, bayonet forceps, cotton strips, sterile swabs (for culture), nasal decongestants, and topical anaesthesia are essential.

After the patient has been seated directly facing the examiner, and without any extension or flexion of his head, the external nose, as well as the remainder of the face, is first carefully examined by observation and palpation. The presence of redness, swelling, or ecchymosis, or loss of structure or support is determined. The nasal speculum is inserted into the nose and directed away from the nasal septum in order to avoid unnecessary discomfort for the patient. Also overdilating the external nasal orifice is avoided, for this can cause the patient an undue amount of pain. The color of the nasal mucous membrane is observed and it is determined whether the turbinates are normal, hypertrophic, or atrophic. The nasal septum is observed carefully for deviations. Abnormalities in the nasal vestibule can be readily seen.

Next, the nose is sprayed with 0.25% Neo-synephrine, 1% ephedrine solution, or 0.51% cocaine solution and, after a few minutes, is reexamined. If the posterior aspect of the nasal cavities cannot be seen, additional spray decongestant is applied to the nasal mucous membrane. With adequate decongestant of the mucous membrane, the entire nasal cavity and superior aspect of the nasopharynx can be seen. If instrumental palpating or probing is to be carried out, or if a biopsy specimen of a lesion is to be obtained, it is best to anesthetize the mucous membrane of the nasal cavity with cotton strips impregnated with 4% cocaine or 2% Pontocaine solution. Cultures and smears are taken as soon as abnormal discharge is seen.

Physiology

A sound knowledge of nasal physiology is necessary in order to evaluate normal and abnormal findings properly. The three major functions of the nose are: (1) respiration, (2) olfaction, and (3) phonation. Only a brief review of these functions is included in this text.

Respiration. Approximately 500 cubic feet of air pass through the nasal cavities every 24 hours. The nose warms, filters, and moistens this air. In order to accomplish these functions, there must be a large surface area of moist mucous membrane. The mucous film covering the nasal mucosa must be in constant motion as it replenishes itself. There must be normal airways, a sufficient air supply from the cavernous spaces, and a constant pH for the nasal secretions. On inspiration, very little air passes through the middle and superior meatuses. The reverse is true with expiration. The ostia of the paranasal sinuses are thus not subjected to cold or dry air. The negative pressure caused by inspiration is important in the evacuation of the paranasal sinuses. There is gross filtration by the vibrissae in the nasal vestibule. The mucous film and ciliary action take care of fine particles. Lysozyme found in the mucous film destroys certain bacteria. A secondary line of defense against infection is situated in the stroma of the mucous membrane. It is made up of histiocytes which engulf and destroy bacteria. The nasal cilia are 7 microns in length and beat eight to twelve times a second, with a rapid effective stroke followed by a slower recovery stroke. The direction of sweep of these cilia is away from the ostia of the sinuses and in the direction of the nasopharynx. The action of these cilia in the anterior third of the nasal cavity is relatively slow, but rather rapid from the tip of the turbinates, posteriorly.
Olfaction. The olfactory epithelium is located in the superior aspect of the nasal cavity. The olfactory mucous membrane is yellow or brownish in color and extends down onto the septum and lateral nasal wall for a distance of 5 to 8 mm. The total olfactory area is approximately 500 sq mm. The sense of smell is sometimes referred to as "taste at a distance." Taste and smell are closely connected in the central nervous system, and it is often difficult to disassociate one from the other. Constant exposure to any odor can produce fatigue. This fatigue also interferes with new or different stimuli. The mechanism of olfactory discrimination is unknown. Reflexes from the olfactory system can produce salivation and gastric secretion. Reflexes from the nasal mucous membrane can result in sneezing, lacrimation, respiratory inhibition, or vasomotor response.

Phonation. Together with the paranasal sinuses the nose gives resonance to the sounds produced by the vocal cords.

Nerve Supply

Included in the nerve supply to the nose are the following:

1. The nasociliary nerve. This nerve arises from the ophthalmic nerve and lies in the lateral wall of the cavernous sinus. It enters the orbit through the superior orbital fissure and passes obliquely across the orbital cavity to the anterior ethmoid foramen, which lies in the medial wall of the orbit. The posterior ethmoid branch leaves the orbit by way of the posterior ethmoid foramen. The other branch of the nasociliary nerve inside the orbit is the infratrochlear nerve. The anterior and posterior ethmoid nerves leave the orbit through the ethmoid foramina and thus reenter the cranial cavity. They then pass along the cranial surface of the cribriform plate before entering the nasal cavity.

2. The anterior ethmoidal nerve. The medial or septal branch of this nerve supplies the anterior septum as far as the nares. Its lateral branch supplies the anterior portions of the middle and inferior turbinates, anterior ethmoid cells, frontal sinus, and anterior middle and inferior meatuses. Its lateral nasal nerve is a branch which passes between the nasal bone and upper lateral cartilage to supply the tip of the nose.

3. The posterior ethmoidal nerve. This nerve supplies only a small area of mucous membrane, posterior ethmoid cells, and sphenoid sinus.

4. The sphenopalatine nerve. The maxillary nerve leaves the cranial cavity by way of the foramen rotundum and enters the pterygopalatine fossa where the sphenopalatine ganglion is found. The nasal branches of the sphenopalatine ganglion enter the nasal cavity through the sphenopalatine foramen, located just behind the posterior end of the middle turbinate.

The medial postero-superior branch of the sphenopalatine nerve supplies the posterior nasal septum and continues on as the nasopalatine nerve which passes through the anterior palatine (Scarpa's) foramen to supply the hard palate. Before reaching the foramen it anastomoses with the nasal branch of the antero-superior alveolar nerve. Here the medial postero-superior branch of the sphenopalatine nerve and the nasal branch of the antero-superior alveolar nerve supply the infero-anterior surface of the inferior turbinate and the adjacent floor. After anastomosing they pass together through the intermaxillary suture.
(foramina of Scarpa) to supply the hard palate behind the upper teeth. At this location they anastomose with branches of the greater palatine nerve.

The lateral postero-superior branch of the sphenopalatine nerve supplies the superior and middle turbinates (large portion) and has branches to the posterior ethmoids.

The lateral postero-inferior branch of the sphenopalatine nerve is where the sphenopalatine ganglion gives off the great or anterior palatine nerve which passes through the pterygopalatine canal within the lateral nasal wall. Here it gives off branches to the postero-inferior turbinate and posterior middle and inferior meatuses.

5. The infraorbital nerve. This nerve gives off a branch which supplies the lateral surfaces of the external nose, the ala nasi and also the lower end of the septum, by way of the external nares.

6. The antero-superior alveolar (dental) nerve. This nerve gives off a branch which pierces the lateral wall of the nose to supply the anterior portion of the inferior meatus and adjacent nasal floor.

7. The nervi terminales. The ganglion cells of these nerves, which pass through the cribriform plate, lie between the crista galli and the olfactory bulb. The nerves lie in the deepest portion of the nasal septal mucosa, over the cartilaginous portion of the septum. Their function is not known. They are thought to be both sensory and autonomic.

The parasympathetic system of the nose includes the facial nerve, intermediary nerve, greater superficial petrosal nerve, and the sphenopalatine ganglion. This system has a vasodilatory and secretory function.

The sympathetic system of the nose includes the superior cervical sympathetic ganglion, the internal carotid arteries, the deep petrosal nerve, vidian nerve, vidian canal, and sphenopalatine ganglion. Its function is vasoconstrictory.

The sensory elements of the external nose are:

1. Branches of the infraorbital nerve.

2. Branches of the infratrochlear nerve, which is a branch of the nasociliary, and thus of the ophthalmic branch of the fifth cranial nerve.

3. The lateral nasal nerve, which is branch of anterior ethmoid nerves.

The motor elements of the external nose are in the muscles supplied by the seventh nerve.

Included in the arterial supply to the nose are the following:

1. Branches of the internal carotid artery. These include the anterior ethmoid arteries with their branch of the ophthalmic arteries, and the posterior ethmoid arteries with their
branch of ophthalmic arteries. The course and distribution of the ethmoid arteries are similar to those of the nerves.

2. Branches of the internal maxillary artery. The sphenopalatine arteries pass with the nerve through the sphenopalatine foramen. The lateral branches supply most of the turbinates. The nasopalatine or septal branch courses along with the nerve. The descending palatine artery accompanies the greater palatine nerve down into the pterygopalatine canal. Like the nerve, it sends twigs to the lower posterior part of the nasal cavity. It passes through the greater palatine foramen, sends branches to the soft palate, and runs forward as the major palatine artery. Anteriorly it passes through the incisive foramen to the septum and laterally through the foramen of Stensen to anastomose with the nasopalatine branch of the sphenopalatine artery to supply the anterior floor. The infraorbital artery has the same distribution as the nerve.

The postero-superior alveolar branch arises near the pterygopalatine fossa, courses through the alveolar foramina of the maxilla and goes on to supply the maxillary antrums.

3. The external maxillary artery. The angular branch includes the branch of the facial artery and supplies the lateral aspect of the nose, the skin of the vestibule, and the dorsum of the nose. The superior labial artery supplies the vestibular portion of the septum. Little's (Kiesselbach's) area includes the anterior ethmoidal arteries, the nasopalatine (septal) branch of the sphenopalatine arteries, the branch of greater palatine arteries which passes from the palate through the incisive foramen, and the branch of the superior labial arteries.

**Normal Findings**

The nasal vestibule varies considerably in different individuals as to size and shape. It is bound medially and laterally by the crura of the greater alar cartilage. It is lined with fibro-elastic tissue and skin which are tightly adherent to the underlying cartilage. The anterior nasal septum and anterior tips of the middle and inferior turbinates can be seen without the use of a nasal decongestant. The line of transition from squamous to respiratory epithelium can be easily identified.

After the nasal cavity has been decongested, the four walls are easily seen unless some abnormality is present. The floor is mostly made up of the hard palate. A portion of the nasal surface of the soft palate can also be seen. The nasal septum makes up the medial wall. By palpation, the anterior cartilaginous portion can be distinguished from the bony portion, which is made up of the septal process of the palate, the vomer, and the perpendicular plate of the ethmoid bone. The mucous membrane is rather tightly adherent to the septum. Superficial blood vessels, especially those located anteriorly in Little's area, can be seen. A thickening of the mucous membrane of the septum opposite the anterior tip of the middle turbinate is known as the septal tubercle. The roof of the nasal cavity is quite difficult to view. Where the mucous membrane changes from a pinkish to a yellowish hue the olfactory epithelium begins. The most prominent structure on the lateral nasal wall is the inferior turbinate. This is a separate bone which articulates with the lacrimal, ethmoid, and palatal bones. The mucous
membrane is quite thick, for it contains numerous venous plexus in the form of cavernous erectile tissue. The inferior meatus is inferior to the inferior turbinate. For the most part it corresponds to the medial wall of the maxillary sinus. The nasolacrimal duct opens high in the anterior portion of the inferior meatus. The middle turbinate is a projection of the ethmoid bone. It obstructs a good view of the middle meatus. In some patients the middle meatus can be seen, especially when the mucous membrane of the middle turbinate is atrophic. The ethmoidal infundibulum is a crescent-shaped groove seen just anterior to an elevation known as the ethmoidal bulla. The opening into the infundibulum is known as the semilunar hiatus. The nasofrontal duct may be positioned in the superior aspect of the infundibulum. Just inferior to this are the openings of the anterior ethmoid cells. The ostium of the maxillary sinus is found inferiorly and posteriorly in the infundibulum. In some individuals a superior turbinate can be seen; usually, however, only a thickening of the mucous membrane can be identified. The superior meatus and the ostia of the posterior ethmoid cells are found in this area. Posterior to this area is the sphenoid sinus. The ostium of the sphenoid sinus is located posteriorly.

Abnormal Findings

Disorders of Nasal Vestibule. The nasal vestibule is a common site for furuncles and fissures. Most deformities of the nasal vestibule are caused by dislocation of the septal cartilage at the columella. These deformities may also be due to the variation in size and shape of the alar cartilages. This area is not an uncommon site of benign and malignant skin tumors.

Disorders of Mucous Membrane. The color of the mucous membrane is noted. Normally it is a deep pink, but with inflammatory processes or nasal allergy, it may be reddened or pale and of a bluish-gray color. The mucous membrane should be evaluated for the presence of hypertrophy or atrophy; also the quantity and character of nasal secretions should be carefully studied. The swollen mucous membrane associated with allergy usually has a watery discharge. When vasomotor rhinitis is suspected, it is most important to determine whether or not there is an excessive amount of mucous secretion. Hypertrophy of the turbinates and mucous membrane associated with hypersecretion of mucus is probably not due to a true vasomotor rhinitis, and therefore a good response to either a medical or a surgical regimen directed toward therapy of this type of rhinitis cannot be expected. The hypertrophy may an early phase of atrophic rhinitis. Smears should be made to determine whether or not eosinophils are present. The protein and sugar content of the secretions can be easily ascertained with a lab stick. A watery rhinorrhoea can represent a leakage of spinal fluid. It is usually best to take samples for cultures before applying vasoconstrictors; on the other hand, purulent secretions may not be obtained prior to vasoconstriction.

Irregularities of Septum. There is almost always some degree of septal irregularity (except, possibly, in the Bantu people of South Africa). Quite commonly there is a ridge located inferiorly on one or both sides where the septal cartilage joins the septal process of the palatal and vomer bones. As a rule these minor irregularities are symptomless; too often they are taken as a cause for nasal stuffiness which is due to other factors and an unnecessary submucous resection of the nasal septum may be performed. On occasion, ridges, spurs, or deflections of the nasal septum, which do interfere with normal nasal respiration, can be seen.
Septal spurs can, on occasion, initiate nasal neuralgia manifested by a severe, intermittent or constant, boring pain, usually in the lateral aspect of the nose, over the maxilla, but may be located in any area supplied by the second division of the fifth cranial nerve. In making the diagnosis, the spur and surrounding area should be anesthetized with a topical agent. If this is not effective in relieving the pain, the sphenopalatine ganglion should be anesthetized to determine if the pain is due to sphenopalatine neuralgia.

**Stuffiness or Obstruction.** The most common symptom of nasal disease is stuffiness or obstruction. This may be unilateral or bilateral. A deviated nasal septum is the most common cause of unilateral stuffiness or obstruction. Operation for its correction should be advised only if the symptom is distressing or the deviation causes complicating sinus disease.

Foreign bodies are not uncommonly found in the nasal cavity. They may produce a reaction which in turn leads to stuffiness or obstruction. They are encountered most commonly in children and in psychotic patients. In addition to stuffiness, they may be responsible for pain, bleeding, and a foul discharge. The diagnosis is made by palpation with a probe, after a topical anesthetic has been applied, and also by x-ray examination. Removal of intranasal foreign bodies can be quite difficult and often a general anesthetic is required.

Acute and chronic rhinitis, hay fever, and vasomotor rhinitis are the most common causes of bilateral nasal stuffiness and obstruction in adults; adenoid hypertrophy is the most common cause in children. If adenoid hypertrophy is persistent or associated with recurrent or persistent sinusitis or middle ear disease, an adenoectomy is indicated. A deviated septum may cause bilateral nasal stuffiness, especially when the septum is deviated to one side anteriorly and to the other posteriorly. Nasal polyps, a chronic edematous inflammatory process of the nasal mucous membrane, may be responsible for bilateral obstruction. They appear as yellowish, grape-like masses and are usually associated with bilateral chronic allergic ethmoiditis. Other sinuses may also be involved.

Hematoma of the septum produces bilateral nasal obstruction. It is usually of traumatic origin, or it may follow submucous resection of the nasal septum. Abscess of the nasal septum presents as bilateral nasal obstruction with pain, redness, and swelling of the septum on both sides. Both hematoma and abscess of the nasal septum require surgical therapy.

**Benign Tumors.** Papillomas appear in the region of the nasal vestibule as viable, sessile masses. Osteomas can extend into the nasal cavity. They quite often produce external deformity as well as nasal obstruction. Juvenile angiofibromas occur posteriorly. They are more common in males than in females and rarely are seen in persons beyond 20 years of age.

**Malignant Tumors.** The most frequently occurring intranasal malignant lesions are of epithelial origin. Often their presenting symptom is unilateral nasal obstruction; therefore, an excellent course to follow is to regard unilateral nasal obstruction as due to a malignant tumor until proven otherwise. Adenocarcinoma is the next most common malignant lesion. Lymphosarcoma, melanoma, and other malignant tumors also may occur in the nose. Malignant intranasal tumors may be manifested by bilateral as well as unilateral nasal stuffiness or obstruction, by external swelling, bleeding, discharge due to secondary infection, pain, and/or epiphora.
Perforation of Nasal Septum. The nasal septum may be perforated either anteriorly or posteriorly. Although such association is uncommon today, we still must think of an anterior perforation as indicative of tuberculosis and a posterior perforation as due to syphilis. At the present time, most perforations are anterior and are the result of trauma from chronic nose picking or are due to surgical procedures. Small anterior perforations are quite troublesome, for they produce a whistling nasal respiration. These can be repaired surgically. The nasal stuffiness or obstruction associated with septal perforation is due to crusting. Epistaxis from the margin of a perforation is common, especially if the patient has not learned how to use saline irrigations and to apply petroleum jelly to the margins of the perforation.

Unilateral Partial or Complete Choanal Atresia. Unilateral choanal atresia often remains undiagnosed, even in adults. In addition to the nasal obstruction, a mucoid or purulent nasal discharge is present. The diagnosis can be made by anterior rhinoscopy, probing, or contrast radiography. Bilateral choanal atresia becomes apparent in the neonatal period. Since the newborn cannot breathe through his mouth, if he has this congenital abnormality he will die from asphyxiation unless the attending physician is alerted to the necessity of an oral airway. Diagnosis is made by attempting to pass rubber catheters from the nose into the pharynx. To confirm the diagnosis and outline the obstruction, radiopaque substances are instilled into the nasal cavity, and lateral x-ray views are obtained with the infant in the recumbent position.

Paranasal Sinuses

History

Much of the history of sinus disease is obtained during the interrogation for nasal signs and symptoms. The most common symptom of sinus disease is nasal discharge. It is, however, important to review carefully the history of discomfort or pain related to the various paranasal sinuses. Generalized headache is usually not a symptom of sinusitis. Pain from the frontal sinus can be present directly over the sinus or in the orbit. This pain appears each morning and progresses in severity until late afternoon, at which time it subsides spontaneously. Pain from the maxillary sinus can occur directly over the sinus, in the orbit, or at the upper teeth. Pain from the ethmoid sinus is usually in, or medial to, the orbit on the affected side. The pain resulting from sphenoid sinus disease is most difficult for the patient to describe. It is usually severe, persistent, and emanates from the "center of the head." A change of head position may either worsen or relieve the pain.

There are numerous orbital manifestations of sinus disease. These include orbital pain, exophthalmos, enophthalmos, lid swelling, mass in the orbit, epiphora, orbital cellulitis, and abscess (see Chapter 2).

Anatomy

The anatomy of the paranasal sinuses will be discussed in detail in the following chapters along with surgical technique. A thorough knowledge of the anatomy, with its variations, is essential for the diagnosis and treatment of sinus disease.
Technique of Examination

Examination of the sinuses should include palpation of the roof and floor of the orbits, of the ascending process of the maxillae, and of the canine fossae. Tenderness may be elicited in these areas, and masses or defects may be felt. Transillumination is of limited value but should not be excluded. Its use is limited to the diagnosis of frontal and maxillary sinus disease. For the frontal sinuses the light is placed under the medial aspect of the supraorbital rim for observation of the forehead; for the maxillary sinuses it is placed above the infraorbital rim for observation of the hard palate. The test is not of true diagnostic value, for both the frontal and maxillary sinuses vary considerably in their degree of development. A sinus filled with clear liquid will transilluminate well. The presence of a mass, thickness, or reaction in the surrounding bone will interfere with transillumination. Transillumination is most useful as a tool for following the patient's progress once a clinical or radiographic diagnosis has been made.

During infancy, the frontal and sphenoid sinuses are not clinical entities. The frontal sinus is an extension of an anterior ethmoid cell and is usually not fully developed until puberty. In approximately 5% of the population there is no frontal sinus development; in 15 to 20%, only unilateral pneumatization is found above the supraorbital rim. The sphenoid sinus at birth is a definite structure in the posterior nasal cavity. Pneumatization extends into the sphenoid bone when the child is approximately 3 years of age. Full pneumatization is reached during adolescence. The maxillary and ethmoid sinuses are present at birth and thus can be diseased during infancy. This is especially true of the ethmoid sinuses. Neither the maxillary nor the ethmoid sinuses, however, reach full development until adolescence.

Technique of Radiography

By Alexander S. Macmillan, Jr, MD.

Tabletop screen technics are very effective in paranasal sinus radiography. A stainless steel lead-backed mask, 6 inches in diameter, is placed over a 6.5 x 8.5-inch cassette for each view. An off-center mask, 4 inches in diameter, is useful for obtaining both optic foramina on one film and for stereoscopic views. Five standard projections are used: (1) PA (Caldwell), (2) erect Waters', (3) prone Waters', (4) basal, and (5) lateral.

The following accessory projections are employed when necessary to show more clearly areas that are not well defined on the standard views: (1) optic foramina, (2) dental films, (3) AP and lateral laminagrams, and (4) lateral soft-tissue films. Various film combinations can be used for special purposes: (1) upright and cross-table lateral views for fluid levels, especially in the sphenoid sinus, (2) lateral and basal views for nasopharyngeal neoplasm, and (3) PA, Waters', basal, lateral and optic foramen views plus laminagraphy to determine the extent of injury after trauma.

Tabletop screen technic is adaptable to all ages and conditions of patients because of the optimal object-film distance and short exposure time. Infants are wrapped in a sheet, mummy style, for immobilization, and the standard or accessory projections are used.
We line up our five views in the above order much as one would study the facial bones and sinuses of an anatomical skull:

(1) On the Caldwell view we look the skull 'in the eye.' This is the best view of the frontal bone and sinuses, the ethmoids, and orbits and the upper aspect of the antra. The floor of the back or apex of the orbit projects above the inferior orbital rim.

(2) The erect Waters' view is taken with the orbito-meatal line at a 45° angle to the central beam. This gives the most satisfactory view of the facial bones, especially for injuries. The orbital floor is projected below the lower rim of the orbit due to parallax.

(3) In the prone Waters' view, the skull is tilted back a little more. The prone and upright Waters' views will often permit stereoscopy.

(4) The basal view is best made in the prone position with the orbito-meatal line as close to parallel to the cassette as possible and the central beam angled slightly caudally and passing through the angle of the mandible.

(5) The (erect) lateral view is usually made with the patient facing left.

Individual variations in facial features (size, shape, etc) need not be considered in positioning the patient or in angling the beam. The orbito-meatal line, sagittal plane and other surface landmarks guarantee consistent reproducibility on subsequent examinations. The central ray is always aligned to the center of the film. The mask, slightly raised above the cassette, is a convenience in accurate positioning and provides sharp edges to the exposure area on the films. We omit the mask on the lateral view.

Some Principles of Interpretation

1. The radiologist must have the patient's history at hand when reporting the films.

2. Be specific in recording your impressions. We use the term, 'density due to ...', thereby committing us to attempt a pathologic correlation, much as Fleischner, in described a blunted costophrenic angle, says, 'It is obscured by fluid, old pleurisy, tumor, etc.'

3. Displacement of air from a sinus results in increased density. An overlapping lesion outside the sinus usually has a negligible effect on the density. Feldman demonstrated this by placing bolus material over a maxillary sinus and exposing a film. It is well recognized that only the peripheral contours of a breast shadow are seen on a chest film while an epicardial fat pad is usually as dense as the heart.

4. Mucosal thickening can be determined only when seen in true tangent, as on the antronasal wall.

5. Blood in a maxillary sinus from an orbital floor fracture does not obscure the fragments. The fragments cannot be seen because they are displaced so that their flat side faces the central beam.
6. The orbital floor and optic foramina are bilaterally symmetrical.

7. An asymptomatic primary focus of cancer is commonly found in the nasopharynx but seldom in the sinuses.

8. Maxillary retention cysts are smooth in outline and are seen on the roof, lateral wall, or floor of the sinus. Rarely does cancer present in a sinus as an isolated mass unless it is irregular and then there usually is bone destruction.

9. Bone destruction usually means malignant disease but infection and benign lesions may on occasion erode bone.

10. Cellulitis over a maxillary sinus should alert the radiologist to study the teeth carefully for a periapical abscess in the upper jaw. It is rare for maxillary sinusitis to 'break out' of its confines whereas such extension from the frontal and ethmoid sinuses is common.

Nasopharynx

Anatomy

The nasopharynx extends from the bony choanae to the inferior border of the soft palate. Looking anteriorly from the nasopharynx into the nose, the posterior border of the nasal septum dividing the two choanae is seen. The posterior tips of the middle and inferior turbinates can be identified in each choana. The lateral and posterior walls of the nasopharynx are formed by mucous membrane which covers the superior constrictor muscles.

Adenoid tissue, a mass of lymphoid tissue also known as the pharyngeal tonsil, is found on the posterior wall of the nasopharynx. It is connected with the palatine and lingual tonsils by a band of lymphoid tissue extending down the lateral pharyngeal wall. This entire lymphoid complex is known as Waldeyer's ring.

In the superior aspect of the lateral wall of the nasopharynx is a depression known as the pharyngeal recess (sinus of Morgagni or fossa of Rosenmüller). This is formed by a deficiency in the muscle insertion of the superior constrictor to the base of the skull. Below the pharyngeal recess is the eustachian tube cartilage. This is called the torus tubarius. A ridge extending downward from the torus tubarius to the lateral pharyngeal wall is often referred to as the salpingopharyngeal fold.

The anterior wall of the nasopharynx is formed by the hard and soft palate.

Physiology

Inspired air passes into the oropharynx from the nose by way of the nasopharynx. The mucous blanket (mentioned under the discussion of nasal physiology) passes from the nose into the oropharynx by way of the nasopharynx. The nasal mucosa, under normal conditions, produces approximately a quart of seromucinous fluid a day. When this amount is decreased by intranasal and environmental factors, the mucous blanket becomes greatly thickened. This
blanket, which is normally insensible, thus becomes sensitive by virtue of being concentrated and is referred to as a postnasal drip.

The nasopharyngeal space, with the nasal cavities, is also concerned with the resonant quality of the voice.

**Technique of Examination**

**Mirror Examination.** A mirror, size #0 to #00, is used to examine the nasopharynx. It is warmed by a flame, hot water, or by holding it over an electric light bulb. If no heat is available, a thick soapy solution is placed on the mirror and wiped off without rinsing. The patient should be sitting directly in front of the examiner, with his head at the same level as that of the examiner. The patient is asked to sit erect, all the way back in the chair, with his head projected slightly forward.

The examiner depresses the patient's tongue onto the floor of the patient's mouth with the left hand, making sure not to extend the tip of the tongue blade beyond the patient's mid-tongue area. Light is reflected into the pharynx with the head mirror. The examiner grasps the mirror with his right hand as he would grasp a pencil and slips it behind and to one side of the patient's uvula. The patient is requested to breathe quietly and not to hold his breath. Care is taken not to touch the base of the patient's tongue. Two percent Pontocaine, or 4% cocaine, solution may be sprayed into the pharynx to control the gag reflex. The soft palate may be retracted anteriorly for a better view of the nasopharynx by placing a rubber catheter, which exits through the oropharynx, into each nostril. The catheters are stretched and clamped over a piece of rolled-up gauze placed just below the nose.

**Anterior Rhinoscopy.** The upper nasopharynx can be examined, after proper shrinkage of the nasal mucosa (with 1% ephedrine or 0.5% cocaine), by direct examination of the nose through a nasal speculum.

**Nasopharyngoscope.** The nasopharyngoscope is an instrument similar to cystoscope. It provides an excellent view of all areas of the nasopharynx.

**Palpation.** Palpation is usually reserved for examination with the patient under general anesthesia. Topical anesthesia relieves some of the discomfort of this examination.

**Direct Examination.** A tubular instrument known as the Yankauer speculum provides direct inspection of the nasopharynx by lifting the soft palate out of the way. This instrument, however, is only suitable for examination of the lower half of the nasopharynx.

**X ray.** The lateral view of the nasopharynx is used to determine the following:

1. Size of adenoids.
2. Status of eustachian tubes.
5. Patency of choanae (using radiopaque substance).
7. Ability of soft palate and transverse ridge of contracted superior constrictor (known as Passavant's ridge), at level of soft palate, to close the velopharyngeal space.

8. The boundary between the nasopharynx and the oropharynx (this x ray is taken during the act of swallowing).

The base of skull view demonstrates:

1. Presence of lesions.
2. Size of lesion.
3. Extension of disease beyond the nasopharynx (bony destruction).

**Symptoms of Nasopharyngeal Disease**

**Nasal Obstruction.** Impaired or obstructed nasal airways are not always due to intranasal disease.

Unilateral or bilateral choanal atresia may be due to bony or membranous obstruction. Bilateral atresia occurring in the neonatal period presents an emergency situation, for mouth-breathing is an acquired habit.

**Choanal Polyp.** A large polyp may extend from the middle meatus into the nasopharynx and cause obstruction.

**Benign Tumors.** Fibromas and other benign tumors (neurofibroma, hemangioma, mixed tumor, chondroma, and lipoma) may arise in the nasopharynx.

**Cancer of the Nasopharynx.** Cancer of the nasopharynx represents 2% of all malignant growths. It is most common in the Oriental population. A mass in the neck or serous otitis media due to blockage of the eustachian tube may be the first symptom.

**Cysts.** Cysts may form in the upper posterior wall of the nasopharynx at the site of evagination of embryonic structures which form the pituitary gland (Rathke's pouch).

On the lower posterior wall, a cyst may form from the sac-like depression known as the pharyngeal bursa. This area is the point of union between the anterior end of the notochord and the pharyngeal endoderm (Thornwaldt's cyst).

**Adenoid Hypertrophy.** Adenoid hypertrophy is the most common cause of nasopharyngeal obstruction.

**Bleeding.** Bleeding from the nasopharynx may have its origin in the nose. Benign and malignant tumors, varices, and atrophic mucous membrane may be the sites of hemorrhage.

**Discharge.** In addition to "postnasal drip," described under the heading "Physiology," the following may account for nasopharyngeal discharge:

1. Purulent sinusitis.
2. Nasal allergy.
3. Atrophic nasopharyngitis.
4. Infected pharyngeal bursa.
5. Acute infection of the nasopharynx.

Cranial Nerve Paralysis. Cranial nerve palsy may result from extension of disease from the nasopharynx. The sixth cranial nerve is the one most commonly paralyzed. Next in order are the third, fourth, and fifth cranial nerves.

Hearing Loss and Otalgia. Almost any disease process in the nasopharynx may obstruct the eustachian tube orifice, producing discomfort and blockage of the ear. The blockage of the eustachian tube results in a negative middle ear pressure and thus exudation of serum.