TITLE- SPECTRUM OF VARIANTS IN CT PARANASAL SINUS

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Abstratct:- We conducted prospective descriptive study in 229 patients who underwent CT PNS for non sinus related indications with aim of the study was to evaluate the incidental CT findings in the paranasal sinuses in asymptomatic population. Data was evaluated in terms of the frequency of anatomical variant, incidence in particular age and sex within the study population.An exclusion criteria was maintained in the study to exclude patients who had symptoms suggestive of paranasal sinus disease or in patients reliable history could not be obtained.

Keywords-CT PNS , Anatomical variants , Asymptomatic population , Paranasal sinuses

INTRODUCTION

The paranasal sinuses are mucosa-lined structures physically contiguous with the nasal cavity. They were first described by Leonardo da Vinci in the publication “Two View of the Skull”. Since his description, numerous theories have been espoused on the anatomical or physiologic importance of the sinuses in humans. These include insulation, reducing cranial weight, heating and humidifying the air, imparting resonance to the voice, providing airway defense and simply to replace functionless bone. Despite the proliferation of theories, their functional role remains a mystery, even prompting some authors to argue that they have proved much more of a liability than an asset [Evans, 1992]. However, sinusitis continues to be one of the most prevalent disorders encountered in general medicine practice (Reuler et al, 1995) as well as in the otorhinolaryngology (E.N.T.) department.

Sinusitis is rarely life threatening, but the complex anatomy of the facial planes, the associated venous and lymphatic spread and the close location to the central nervous system can lead on to serious complications.

It is important to understand the normal anatomy and physiology of the paranasal sinuses in order to understand the pathogenesis of sinus disease. There are four pairs of sinuses named for the skull they pneumatize. They are the maxillary, ethmoid, frontal, and sphenoid sinus air cells and they are lined by pseudostratified columnar epithelium bearing cilia. The mucosa contains goblet cells that secrete mucus, which aids in trapping inhaled particles and debris.

The ostiomeatal complex encompasses the frontal recess, ethmoid infundibulum, hiatus semilunaris and middle meatus. It constitutes the common drainage pathway of the frontal, maxillary, and anterior ethmoid air cells and patency of the ostiomeatal complex is critical for normal sinus drainage and ventilation [Gotwald et al, 2001].

Numerous pathological processes including allergy, viral infections and pollutants cause sinonasal mucosal inflammation leading to occlusion of the ostiomeatal complex [Yonkers, 1992]. Mucosal swelling impairs mucociliary clearance and results in sinus ostia obstruction. Sinus excretions then pool and thicken, creating a nidus for superinfection.

Conventional radiography has been mostly superceded by CT as the investigation of choice for evaluation of the paranasal sinuses. CT is now the technique of choice for the preoperative evaluation of the nose and paranasal sinuses and is the gold standard for delineation of inflammatory sinus disease resulting from obstruction [Duvoisin et al, 1991]. Bony algorithm can be used for excellent anatomical delineation. Coronal CT images most closely correlate with the surgical approach. A non-contrast CT scan is usually sufficient, except for complicated acute sinusitis.

MRI is inferior to CT for demonstration of the bony anatomy for pre-operative planning in FESS. However, it is the investigation of choice for demonstration of the intranasal and orbital complications of sinus disease [Hahnel et al, 1999]. It can also be used to assess therapeutic success and also for follow up with the advantage of avoiding the radiation exposure of CT. Cost, of course, is a limiting factor whenever MRI is considered, especially in developing countries like India.

As mentioned above, the primary role of CT is to aid in the diagnosis and management of recurrent and chronic disease and to define the bony anatomy before surgery. Sinus disease usually manifests with air-fluid levels, mucosal thickening or opacification of the normally aerated sinus lumen. Acute sinusitis may present with isolated air fluid level while presence of sclerotic, thickened sinus wall supports a diagnosis of chronic sinusitis [Momeni et al, 2007]. Mucosal thickening is common to both acute and chronic sinusitis.

However, findings on CT scan should be interpreted in conjunction with clinical and endoscopic findings because of high rates of false-positive findings and a significant percentage of asymptomatic individuals as well as patients with minor upper respiratory tract infections had abnormalities on sinus CT scans, as we also demonstrated during the course of our study. O'Brian et al [1998] had even observed that demonstration of features of acute sinusitis on CT could be considered as having high sensitivity but low specificity.

Anatomical variants in the para nasal sinus region are another area where there is still a lack of consensus among clinicians as regards their clinical relevance and impact on sinus disease. The variants commonly seen include agger nasi, concha bullosa, haller cells, paradoxical middle turbinate, and onodi cells. During our study we came across all of these variants as well as some rarer ones including vomeral pneumatisation and turbinate sinus.

In this study, we evaluated the CT findings in the paranasal sinus region in 229 patients who presented over a period of one year for non sinus related indications. A significant percentage of these asymptomatic patients were noted to have incidental sinus abnormalities. A statistical comparison was done comparing our study with similar studies done in various other countries. We also noted prevalence of various anatomical variants and tried to find an association between incidental sinus abnormalities and presence of anatomical variants

REVIEW OF LITERATURE

The paranasal sinuses comprise four paired cavities: the frontal, maxillary, ethmoid, and sphenoid sinuses. Each is lined with ciliated pseudostratified columnar epithelium and has a narrow ostium that opens into the nasal cavity.

Functions vary from insulation, reducing cranial weight, heating and humidifying the air, imparting resonance to the voice to providing the first line of airway defense against environmental agents. Particulate matter is trapped by secreted mucus and transported to the pharynx to be swallowed or coughed. The ciliated pseudostratified columnar epithelium contains fibro elastic tissue underneath, which contains both mucous and serous glands. There are both parasympathetic and sympathetic innervations to these glands, the parasympathetic resulting in watery serous secretions, and sympathetic resulting in mucous secretions [Goldstein and Phillips, 1998]. The removal of particulate matter is facilitated by these secretions.

ANATOMY

Frontal Sinuses

The frontal sinuses arise from one of several outgrowths originating in the region of the frontal recess of the nose. Their site of origin can be identified on the mucosa as early as 3-4 months in utero. Less commonly they may arise from the anterior ethmoid air cells of the infundibulum. Their drainage is via the ostium into the frontal recess or via a naso frontal duct into anterior infundibulum.

The frontal sinuses are absent at birth. They start developing around the second year of life [Pandolfo et al, 1987] and reach up into the frontal bone by around 6 years. On average, by the age of 4 years, the cranial extent of the frontal sinuses reaches half the height of the orbit, extending just above the top of the most anterior ethmoid air cells. By the age of 8 years, the top of the frontal sinuses is at the level of the orbital roof, and by the age of

10years, the sinuses extend in to the vertical portion of the frontal bone. The final adult proportions are reaches only after puberty [Scuderi et al, 1993]. Average frontal sinus has been described as 28mm high, 24mm wide and 20mm deep. In 38% of cases, frontal sinus drains into the ethmoidal infundibulum [Laine and Smoker, 1992].

Ethmoidal infundibulum acts as a channel for carrying the secretions from the frontal sinus to the anterior ethmoidal cells and maxillary sinus. In some patients, a frontal bulla develops. This is an upward displacement of the frontal sinus floor caused either by encroachment from the opposite frontal sinus or more frequently by an underlying ethmoid cell. Usually, the frontal sinus contour is slightly scalloped and intra sinus septa may extend in to the sinus from one half to one third height of the sinus cavity. The larger the sinus cavity, the better developed are the septations. Conversely, in a hypoplastic frontal sinus, the sinus is usually a single smoothly contoured cavity devoid of septations.

The frontal sinus can pneumatize both the vertical and horizontal plates of the frontal bone. The deepest area of the vertical portion of the sinus is near the midline at the level of the supra orbital ridge and medial sinus floor and the caudal anterior sinus wall are thinnest in this area. The intersinus septum is the remaining frontal bone between the two frontal sinuses. Septum is usually complete. Focal areas of acquired or congenital dehiscence do occur, allowing inter communication between the frontal sinuses or herniation of the mucosa of one sinus into the contra lateral sinus.

The main arterial supply to the frontal sinus is via the supra orbital and supra trochlear arteries derived from ophthalmic artery. The venous drainage is primarily through the superior orbital vein and the sinus lymphatics drain across the face to submandibular lymph nodes. The sensory innervations of the sinus mucosa is via the supra orbital and supra trochlear branches of the frontal nerve, which is a branch of first division of the trigeminal nerve.

Sphenoid sinus

The sphenoid sinus emerges in the fourth fetal month as evaginations from the posterior nasal capsule into the sphenoid bone. Complete absence of the sphenoid is rare. The sinus starts its major growth in the third to fifth year of life and by the age of 7years the sinus usually has extended posteriorly to the level of the anterior sella turcica wall. By the age of 10-12years, the sinus has usually obtained its adult configuration. The lack of any sinus pneumatisation of the sphenoid bone by the age of 10years is abnormal [Scuderi et al, 1993]. Conversion from red to yellow (fatty) marrow is thought to occur first in the presphenoid plate from the ages of 7months to years [Aoki et al, 1989]. Marrow conversion then extends posteriorly into the basisphenoid plate.
The average sphenoid sinus is 20mm high, 23mm long and 17mm wide. High-resolution CT may show pneumatization of the sphenoidal sinuses as early as 2years of age. Pneumatization progresses in an inferior postero-lateral direction. [Scuderi et al, 1993].

Depending on the degree of pneumatization, the sinus is classified as non pneumatised, pre sellar or sellar. In 60% of the pneumatized sinuses, the sinus cavity extends posterior to the anterior sellar turcica wall and lies under the sella floor.

In 40% of the sinuses, the sinus cavity extends only to the anterior wall of the sella turcica. In less than 1% of cases, the sphenoid sinuses do not develop posteriorly enough to reach the anterior sella wall. The ostium of the sinus is 2-3mm in diameter and 2-3mm from the midline and lies in the upper portion of the intra nasal surface 1.5cms above the floor of the sinus. The sphenoid sinus is usually in the midline anteriorly aligned with the nasal septum.

Thus, from anterior to posterior, the sinus roof is related to the floor of the anterior cranial fossa, the optic chiasma and the sella turcica. The lateral wall is related to the orbital apex, the optic canal, the optic nerve, the cavernous sinus and the internal carotid artery. Posteriorly, are the clivus, pre pontine cistern, pons and basilar artery. The sinus floor is the roof of the nasopharynx and the anterior sinus wall is the back of the nasal fossa medially and the posterior ethmoid laterally. The carotid artery may bulge into the sinus in 65% to 72% of patients and in 4% to 8% of cases; the thin sinus wall separating the two may be absent [Laine and Smoker, 1992].

The arterial supply of the sphenoid sinus is from the branches of both internal and external carotid arteries. The posterior ethmoidal branch of the ophthalmic artery may contribute vessels to the roof of the sphenoid sinus and the floor of the sinus receives blood from the sphenopalatine branch of maxillary artery. The venous drainage flow into the maxillary vein and the pterygoid venous plexus. The sphenoid sinus is innervated from both the second and third divisions of the trigeminal nerve. The posterior ethmoidal nerve from the naso ciliary branch of the ophthalmic division supplies the roof of the sinus and the sphenopalatine branches of the maxillary division supply the sinus floor. The lymphatics drain into retropharyngeal lymph nodes.

Ethmoid sinuses

Ethmoid sinuses are divided into groups of cells by bony basal lamellae that extend laterally to the lamina papyracea and superiorly to the fovea ethmoidalis. These lamellae serve as attachments for the turbinates. There are five lamellae: one for each of the primary turbinates and for each of the secondary turbinates (bulla ethmoidalis and uncinate process). In adults, the lamella is not a straight bony partition.

The basal lamella of the middle turbinate is the most important as it divides the ethmoid into anterior and posterior group of cells that drain into the middle and superior meati respectively [Goldstein and Phillips, 1998]. In addition, the basal lamellae only extend from the posterior portion of the middle turbinate where it is attached to the lateral nasal wall. No basal lamella is present along the anterior portion of the middle turbinate.

The anterior ethmoid cells are more numerous and smaller, whereas the posterior cells are larger and fewer. The adult ethmoid has 3 to 18cells. The anterior ethmoid is further sub divided. These include frontal recess cells draining into frontal recess, infundibular cells draining into the infundibulum and hiatus semi lunaris, and bullar cells draining into a groove on the bulla ethmoidalis called the superior hiatus [Goldstein and Phillips, 1998].

The posterior ethmoid is sub divided into posterior and postreme cells draining into the posterior and postreme meati respectively. The ostia of the ethmoid sinuses are the smallest of all the para nasal sinuses measuring 1-2mm in diameter.

The ethmoid sinuses begin to form in the third to the fifth fetal months, when numerous separate evaginations arise from the nasal cavity. They reach full size by puberty. The lamella prevents one group of cells intermingling with another but they do not prevent intra mural expansion of one group in to another. A concha bullosa results when posterior ethmoid cells extend intra murally to pneumatise the middle turbinate. A posterior ethmoid cell can invade the medial floor of the orbit resulting in a Haller cell. A posterior ethmoid cell can also invade the sphenoid bone: such an extension is usually superior and lateral and is called an Onodi cell. A posterior ethmoid cell` can invade the maxilla and cause a double antrum.

During the first years of life, opacification of ethmoidal air cells is commonly seen in children [Diament et al, 1987]. Pneumatization progresses in a posterior direction, enlarging the posterior air cells until the lateral and medial walls of the ethmoidal sinuses are parallel in the anterior to posterior direction [Scuderi et al, 1993].

The sinus reaches their adult size by the age of 12 years. In the adult, the ethmoid labrynth is pyramidal in shape with its base directed posteriorly. The average dimensions are 4-5cms long, 2.5cm-3cms high, 0.5cms wide anteriorly, and 1.5cms wide posteriorly. The ethmoid bone resembles a cross in coronal section.

The roof of the ethmoid is related to the anterior cranial fossa. The roof of the ethmoid is formed by the orbital process of the frontal bone. The underlying ethmoid cells bulge into this, producing a pitted surface called fovea ethmoidalis. The lateral walls of the ethmoid are related to the orbit. The posterior two third of this surface is formed by the lamina papyracea that covers the posterior ethmoidal cells.

The middle turbinate attaches anteriorly to the ethmoid crest of the ascending process of maxilla and posteriorly to the ethmoid crest of palatine bone. The posterior half of the middle turbinate is loosely attached to the body of the ethmoid bone by the basal lamella and only the posterior tip is attached to the lateral nasal wall at the ethmoid crest of palatine bone. The anterior half of middle turbinate is divided into an upper part called the superior overhang and a lower part called inferior overhang. The division point is a line drawn forward from the upper end of the superior meatus. The inferior overhang is also known as the tip of middle turbinate and is at a lower level than the anterior insertion of middle turbinate. The portion of the lateral wall of the nose between the anterior insertion and the tip of the middle turbinate is known as atrium.

The middle turbinate covers two elevations on the medial wall of ethmoid. The more prominent elevation is the bulla ethmoidalis, which is more posterior and superior. It is an accessory turbinate pneumatized by anterior bulla air cells. The more anterior inferior elevation is the uncinate process. It is also an accessory turbinate and originates from the anterior point of attachment of the middle turbinate. The inferior surface of the ethmoid is related to the medial portion of the roof of the maxillary antrum below. The hiatus semi lunaris marks the inferior extent of ethmoid intra nasally. Thus the superior half of the lateral wall of the nose is formed by the ethmoid and the inferior half by the medial wall of the maxillary sinus.

The posterior ethmoid has a variable relationship with the sphenoid sinus and is intimately related to the optic nerve. The posterior ethmoid cell may extend laterally or superiorly beyond the anterior wall of the sphenoid sinus. The anterior opening of the optic canal may be located adjacent to the most posterior ethmoid cell (50%), at the junction of the posterior ethmoid and anterior sphenoid (25%) or adjacent to the sphenoid sinus (25%) [Ashikawa, 1969]. However, Delano et al [1996] in a study based on coronal CT showed that the optic nerve is mostly related to the sphenoid sinus rather than the posterior ethmoid sinus. Complete bony dehiscence of the optic canal exposing the nerve to injury may be present in 4%-24% of patients [Maniscalo and Habal, 1978; Delano et al, 1996].

The ethmoid sinus receives their blood supply from nasal branches of the sphenopalatine artery and from the anterior and posterior ethmoid arteries, which are branches of the ophthalmic artery. The venous drainage is into the nose via the nasal veins or via the ethmoidal veins, which drain in to ophthalmic and maxillary divisions of the trigeminal nerve. The nasociliary branch of the ophthalmic division supplies the anterior cells via the anterior ethmoidal nerve. The posterior ethmoidal cells are supplied by the posterior ethmoidal nerve from the ophthalmic division and the postero-lateral nasal branches of the spheno-palatine nerve from the maxillary division of the trigeminal nerve. The lymphatics drain into submandibular symphonies.

Maxillary sinus

The maxillary sinus is the first of the paranasal sinuses to develop. The developing maxillary sinus initially lies medial to the orbit. By the end of the first year, the lateral margin of the maxillary sinus extends under the medial portion of the orbit. The sinus reaches the infra orbital canal by the second year of life and passes infero lateral to it during the third and fourth years. By the ninth year the lateral sinus margin extends to the malar bone. Lateral growth ceases by the fifteenth year.

In infancy, the maxillary sinus floor lies at the level of the middle meatus. By the eighth to the ninth year, the sinus floor is near the level of the nasal fossa floor [Alberti, 1976]. If the sinus continues to grow downward, it reaches the actual plane of hard palate by the age of 12 years. The mean dimensions of adult maxillary sinus are 34mm deep, 33mm high and 25mm wide.

The maxillary sinuses lie within the body of the maxillary bone. The groove and canal for the maxillary nerve lie in the middle third of sinus roof. The medial antral wall is the infero-lateral wall of the nasal cavity. The curved postero-lateral wall separates the sinus from the infra temporal fossa. Each sinus has four recesses. They are zygomatic, palatine, tuberosity and alveolar recesses. The floor of the sinus is lowest near the second premolar and first molar teeth. The roots of the three molar teeth form conical elevations that project into the sinus floor.

The inferior turbinate covers the inferior portion of the maxillary hiatus. It attaches anteriorly to the conchal crest of the ascending process of the maxilla and posteriorly to the conchal crest of the palatine bone. The ethmoid bone is the last bone to help close the maxillary hiatus. The ostium of the maxillary sinus is 4mm in maximum diameter. It opens into the nasal cavity through the infundibulum and hiatus semi lunaris. The channel of the infundibulum is 5mm long. Asymmetry in the size and shape of the sinus is common.

The maxillary sinus is supplied by branches of the maxillary artery. The infra orbital, greater palatine, postero superior alveolar and antero superior alveolar arteries contribute to the blood supply. The venous drainage is anteriorly via the anterior facial vein and posteriorly via the maxillary vein. The nerve supply to the antrum is via the branches of the second division of the trigeminal nerve, namely the branches of superior alveolar, anterior palatine and infra orbital nerves. The lymphatics of the sinus drain into the lateral retro pharyngeal and internal jugular nodes and those of the lateral portion of the antrum drain into the submandibular nodes.

Lateral Nasal wall and nasal septum

Projecting from the lateral nasal wall are the inferior, middle and superior turbinate bones or conchae. Occasionally, a supreme turbinate bone can be identified. Beneath each bone lies a respectively named meatus into which the various ostia drain.

The inferior turbinate bone is the largest of the three, under which lies the inferior meatus. The inferior meatus receives drainage from the nasolacrimal duct. Occasionally the duct can be followed from its origin in the infero-medial aspect of the orbit to its ostium in the antero inferior aspect of the meatus, adjacent to the attachment of the inferior concha.

Under the superior turbinate bone, the smallest of the three, lies the superior meatus, through which the posterior ethmoid air cells drain via multiple ostia. The spheno-ethmoidal recess which drains the sphenoid sinus through the sphenoidal ostium lies postero superior to the superior turbinate bone between the anterior wall of the sphenoid sinus and posterior wall of the ethmoid sinus. Lateral to the recess, the most posterior ethmoid air cell and the sphenoid sinus shares a common wall, the spheno-ethmoidal plate [Terrier et al, 1985].

The middle turbinate bone covers the middle meatus. Near the superior attachment of the turbinate bone, a prominence of the lateral wall is produced by the agger nasi cells. Above these lie the frontal recess. The frontal sinus drains via the fronto-nasal duct, agger nasi cells and frontal recess, in the anterior aspect of the middle meatus medial to the uncinate process or directly into the ethmoidal infundibulum [Laine and Smoker, 1992].

The middle turbinate bone attaches to two area of delicate bone, the superior attachment to the delicate lateral aspect of the cribriform plate and the lateral intra ethmoidal attachment of the basal lamella to the thin lamina papyracea of the lateral ethmoidal wall. Posteriorly the basal lamella curves superiorly behind the ethmoidal bullae there by separating the anterior and posterior ethmoid air cells. Ethmoidal air cells located anterior to the basal lamella will drain into the middle meatus, whereas those cells located posterior to the basal lamella will drain into the middle meatus, whereas those cells located posterior to the basal lamella will drain to the superior meatus [Terrier et al, 1985].

The ostio meatal complex

The ostio meatal complex has been referred to as the area between the middle and inferior turbinates that is the confluence of the drainage of the frontal, ethmoidal and maxillary sinuses. It encompasses the frontal recess, ethmoid infundibulum, hiatus semilunaris and middle meatus. The ethmoid infundibulum is bounded laterally by the infero medial wall of the orbit, superiorly by the hiatus semi lunaris and ethmoid bulla and medially by the uncinate process. The maxillary sinus ostium and ethmoid infundibulum constitute the common drainage for the anterior para nasal sinuses [Tan and Chong, 2001].

Ethmoidal infundibulum

The ethmoidal infundibulum is a trough shaped air space that is below the bulla and above and lateral to the uncinate process. Its most anterior portion is formed below by the agger nasi air cells and above by the most anterior portion of the uncinate process. It receives drainage from the anterior and middle ethmoidal air cells and the frontal and maxillary sinuses. Most infundibuli continue superiorly as the fronto nasal duct into the frontal sinus. The exact drainage system of the frontal sinus depends on its embryological development. The drainage usually occurs by way of rudimentary ethmoidal cells into the frontal recess or directly into frontal recess.

Hiatus semilunaris

The hiatus semilunaris gains its name from the arched appearance in the sagittal plane. It runs obliquely in a postero-inferior direction between the uncinate process and the ethmoid bulla. On CT, it is bounded superiorly by the ethmoid bulla, laterally by the medial bony orbit, inferiorly by the uncinate process and medially the middle meatus. The hiatus semilunaris, the final segment of the drainage pathway from the maxillary sinus and ethmoid infundibulum, communicates medially with the middle meatus.

Uncinate process

The uncinate process is a thin curved lamina of bone from the lateral side of the ethmoidal labyrinth that forms a portion of the lateral nasal wall. Anteriorly, it is attached to the nasolacrimal apparatus; inferiorly to the inferior turbinate; posteriorly it has a free margin; and superiorly, its attachment is variable. On CT, the uncinate process can be seen attached inferiorly to the inferior turbinate with the free edge representing the posterior free margin. Anteriorly, the uncinate process may be attached to the lamina papyracea, the skull base or the middle turbinate.

The bullae ethmoidalis

The middle ethmoid air cells produce a round swelling on the lateral wall of the middle meatus whose lateral border forms a portion of the medial orbital wall. Medial to the ethmoidalis and the uncinate process is the middle turbinate. The degree of pneumatization varies considerably ranging from failure of pneumatization (torus ethmoidalis) to a giant ethmoid bulla insinuating between the middle turbinate and uncinate process, displacing the uncinate process medially [Tan and Chong, 2001].

Superiorly the middle turbinate attaches to the cribriform plate at the junction between the fovea ethmoidalis and the cribriform plate. The attachment of the middle turbinate changes direction at its most posterior extent.

Instead of running in an antero-posterior direction it curves laterally and the final lateral attachment of the middle turbinate is oriented in the frontal plane and is called the basal or ground lamella. The most posterior portion of the middle turbinate again runs in a horizontal plane forming the roof of the posterior middle meatus.

The posterior ethmoid air cells lie between the basal lamella and the sphenoid sinus. The basal lamella is the anatomic land mark for separating the anterior and middle air cells from the posterior ethmoid air cells. An air space is usually found between the basal lamella and the bulla ethmoidalis which may extend superiorly to the bulla. This is sinus lateralis. The bulla ethmoidalis may be closed superiorly by the fovea ethmoidalis or it may be separated from the fovea ethmoidalis by the sinus lateralis.

Sinus lateralis and grand lamella

The sinus lateralis is a part of the anterior ethmoid complex. However, it is unlike the other anterior ethmoid air cells that open into the ethmoidal infundibulum and may communicate with the frontal recess or may open directly and independently into the middle meatus via the posterior aspect of the hiatus, which is also called the superior recess of the hiatus semilunaris.

The posterior ethmoidal air cells occupy the posterior ethmoid and the posterior middle turbinate and may invade the sphenoid, palatine and maxillary bones. There are four primary lamella that must be crossed on the way to the ethmoidal bulla, the basal grand lamella and the anterior wall of the sphenoid sinus.

Spheno-ethmoidal recess

Posteriorly, the spheno-ethmoidal recess region drains only the posterior ethmoid air cells and the sphenoid sinus. The sphenoid sinus drains posterior to the superior turbinate directly into the spheno-ethmoidal recess via the sphenoid ostia. The posterior ethmoid air cells however first drain into the superior meatus and subsequently in to the spheno-ethmoidal recess. The drainage from the superior ethmoidal recess is then posterior through the choanae into the naso pharynx.

Mucociliary system

The para nasal sinuses, like the other parts of the upper respiratory system, are lined with a pseudo stratified columnar ciliated epithelium interspread with goblet cells under which is a tunica propria containing mucous and serous glands. The secretions from these glands form surface films of mucous and fluid that cover the epithelium. The abundant mucous secreted by the gland and intra epithelial goblet cells make the surface sticky and moist. This is a very effective system, trapping 80% of particles 3 to 5pm and 60% of particles of 2pm; particles <1pm are filtered through [Goldstein and Phillips, 1998]. The mucous blanket is renewed every 10 to 20minutes [Goldstein and Phillips, 1998].

The dust in the inspired air is deposited on the mucosal surface and the air is humidified. Contaminated mucous film covering the membrane is moved by ciliary action towards the nasal cavity and then into the pharynx. In the para nasal sinus and the nasal cavity, the ciliated epithelium and the mucus blanket form the muco ciliary system which protects the sinuses and the nasal cavity. The mucous blanket is moved by the cilia towards the natural ostium of the sinus, regardless of whether the opening is obstructed or not.

In the frontal sinus mucus passes up along the intersinus septum, then across the roof of the sinus before returning across the sinus floor to the frontal recess and the middle meatus [Evans, 1994]. In the maxillary sinus mucus is moved from the floor of the sinus radially and up the walls of the sinus to the superiorly placed ostium. Each sinus has its own specific pattern of muco-ciliary blanket going towards and ending at the natural ostium.

Placement of an ostium at another site is ineffective as the cilia continue to move the mucous blanket towards the natural ostium.

Poor sinonasal drainage and retention of secretions also occur secondary to apposition of mucociliary surfaces. The ethmoid infundibulum and middle meatus are the areas most commonly affected by anatomical variation leading to such apposition [Stammberger and Wolf, 1988]. Most inspired particles are deposited on the anterior ends of the middle and inferior turbinates and in the anterior middle meatus where their effect will be greatest on the drainage of the anterior ethmoidal cells.

Causes of ostiomeatal obstruction

I **Anatomical Variations**

1. Variation in uncinate process
2. Variations in middle turbinate
   A) Concha Bullosa
   B) Paradoxically bent middle turbinate
   C) Bulging into the lateral nasal wall.
3. Over pneumatized bulla ethmoidalis
4. Over pneumatized agger nasi cells
5. Combination of the above
6. Septal deviation, spur etc.

II Pathological **Variations**

1. Mucosal thickening due to edema or hyperplasia of mucosa secondary to infection or allergy.
2. Polyposis.
3. Synechae in middle meatus
4. Pathological mucous which is thick and viscid blocking the osteo-meatal complex
5. Immotile cilia syndrome.

Patterns of inflammatory sinonasal Disease

There are five major patterns of inflammatory changes in the para nasal sinuses. The first three of these correlate with occlusion of known muco-ciliary drainage routes.

These three distinctive obstructive patterns are:

1) Infundibular unit pattern
2) Ostiomeatal unit pattern
3) Superior ethmoidal recess pattern

   The two additional patterns are

4) Sinonasal polyposis pattern
5) Sporadic or unclassifiable pattern

THE INFUNDIBULAR PATTERN

Maxillary sinus mucosa is swept supero medially by unco ciliary action funneling into the maxillary ostium at the inferior aspect of base of the infundibulum. From there the mucosa is moved into the infundibulum through the hiatus semi lunaris and into the middle meatus. If any obstructive process is present at the base of the infundibulum in the region of the maxillary ostium, the secretions of the ipsilateral maxillary sinus will be prevented from escaping creating isolated maxillary sinusitis.

When CT identifies isolated maxillary sinusitis secondary to obstruction at the inferior portion of the infundibulum, this is referred to as infundibular pattern.

THE OSTIOMEATAL PATTERN

The middle meatus, the infundibulum and the naso frontal ductal system are the important anatomic structures in this pattern. The middle meatus is the air space underneath the middle turbinate. It is the final common pathway for mucous arising in the maxillary, anterior and middle ethmoid and frontal sinuses. Obstruction to the normal movement of the mucosa within the middle meatus may result in the opacification of some or all of the ipsilateral sinuses, depending on the size and precise location of the obstructive process.

More proximal to the middle meatus in the course of the muco ciliary drainage is the infundibulum. At the inferior end of the infundibulum is the maxillary ostium which transmits the mucous drainage of the maxillary sinus. When full blown or complete, this pattern includes the inflammatory involvement within the ipsilateral maxillary, frontal and anterior and middle ethmoid sinuses. Occlusion of the middle meatus is responsible for this pattern of sinus disease [Robert et al, 1992].

A partial ostiomeatal pattern may be seen due to more limited disease within the middle meatus, disease limited to superior infundibulum or the naso frontal duct area. Any combination of the frontal, maxillary and anterior and middle ethmoid sinuses is designated as the OMU pattern [Sonkens et al 1991].

Common abnormalities that have been studied as causes for obstruction of the OMU include mucosal swelling, hypertrophied turbinates, polyps, adhesions, nasal tumors and anatomical variants such as concha bullosa, paradoxical middle turbinate and severe septal deviation with or without spur.

THE SPHENOETHMOIDAL RECESS (SER) PATTERN

When posterior nasal pathology leads to obstruction of sinus ostia in this region, the ipsilateral posterior ethmoid and sphenoid sinuses are involved. This is SER pattern [Sonkens et al, 1991; Robert et al, 1992]. Isolated sphenoid disease or isolated posterior ethmoid sinus disease can be seen in SER pattern due to the different routes of muco ciliary clearance taken by each sinus.

THE SINO NASAL POLYPOSIS PATTERN

This pattern is diagnosed when a combination of polypoidal soft tissue densities are present throughout the nasal vault and paranasal sinuses in association with variable diffuse sinus opacification [Robert et al, 1992].

SPORADIC OR UNCLASSIFIABLE PATTERN

This pattern is specified for cases that do not fit into the first three obstructive pattern or demonstrate evidence of polyposis sinus findings such as retention cysts, mucoceles and mild muco periostial thickening without co existent OMU or SER obstruction.

ANATOMICAL VARIATIONES IN THE PARANASAL SINUS REGION

The middle meatus and lateral nasal wall are subject to wide normal variations that must be distinguished from pathologic changes. These variations may, themselves, be the underlying cause of recurrent sinus disease. However, there is still a lack of consensus among investigators with respect to the prevalence and clinical significance of these variations with some authors reporting them as being encountered with similar frequency in patients being scanned for sinus-related problems, as well as those undergoing evaluation for non-sinus-related problems.

The more common variations can be divided into four groups, depending on the structures involved:

A) Middle turbinate bone
B) Uncinate process
C) Ethmoidal
D) Nasal septum

Middle Turbinate Variations

I. **Concha bullosa**

It is the pneumatisation of the middle turbinate and less commonly of the inferior and superior turbinates [Christmas et al, 2001].

A). Superior concha bullosa

Asymptomatic pneumatisation of the superior turbinate is rare. If the pneumatisation is extensive, a large concha bullosa may cause significant problems by its size alone.

b). Inferior concha bullosa

It is an extremely rare condition [Dogru et al, 1999].

Middle turbinate pneumatisation was first described by Zuckerkandl who coined the term concha bullosa to refer to “distension of the vertical concha by an air cell”.

The middle turbinate bone is usually a thin plate of bone. This plate can become pneumatized by extension of the anterior (55%) of posterior (45%) ethmoidal air cells. The reported prevalence of concha bullosa ranges from 4% to 80% depending on the criteria for pneumatisation and differences in study population [Laine and Smoker, 1992]. “True” concha bullosa (pneumatization of both the vertical lamellar and inferior bulbous portions) is reported in 4-15.7% of the population [Bolger et al, 1991]. If the definition is broadened to include any degree of middle turbinate pneumatization, the prevalence increases to 34% [Zinreich et al, 1988]. The highest prevalence (80%) has been found in patients with chronic sinusitis, prompting Bolger et al [1991] to suggest that concha bullosa may be a contributing factor in the pathogenesis of sinus inflammatory disease, although others do not share this view. Stammberger and Wolf [1988] as well as Lidov and Som [1990] reported that concha bullosa can, when sufficiently large, produce signs and symptoms by encroaching on the infundibulum. Concha bullosa may also contain polyps, cysts, pyoceles, or mucoceles.

Patterns of pneumatisation have been reported depending on localization in the vertical lamella, bulb or involving the entire turbinate with Bolger et al [1991] reporting incidences of 46%, 31% and 15% respectively. Drainage of the concha bullosa ostium has been found to be into the frontal recesses most commonly [Zinreich et al, 1988; Unlu et al, 1994; Hatipoglu et al, 2005]. Other drainage patterns are into the adjacent air cells through the basal lamina and to the hiatus semilunaris. When Hatipoglu et al [2005] compared the concha bullosa types regarding the location of their orifices, the extensive (true) type were mostly draining to the frontal recess and the bulbous type to the hiatus semilunaris.

II. Paradoxically curved middle turbinate bone

Normally, the convexity of the middle turbinate bone is directed medially, toward the nasal septum. When paradoxically curved, the convexity is directed laterally, toward the lateral sinus wall. Bolger et al [1991] reported a 26.1% prevalence of paradoxically curved middle turbinates. It is a presumed etiologic factor because of the deformity and obstruction or alteration of nasal passage air flow dynamics.

Uncinate variations

I. Deviation of the uncinate tip

The superior aspect of the uncinate tip may deviate laterally, medially, or anteriorly out of the meatus, appearing as a second middle turbinate bone [Stammberger and Wolf, 1988]. When deviated medially, it comes into contact with, and compromises, the middle meatus. When deviated laterally, it may encroach on the hiatus semilunaris and infundibulum, impeding drainage and ventilation of the anterior ethmoidal, frontal, and maxillary sinuses.

II. Pneumatized uncinate tip (uncinate bulla)

The exact mechanism by which uncinate pneumatization occurs is not known. It has been proposed that this process is due to growth of agger nasi cells into the most antero-superior region of the uncinate process. Bolger et al [1991] quoted a prevalence of 0.4-2.5%. This variation has been implicated in narrowing of the infundibulum, producing impaired sinus ventilation [Zinreich et al, 1987; Rao and el-Noueam, 1998].

Ethmoidal Variations

I Haller cells (infra orbital ethmoidal cell)

These are ethmoid air cells that develop into the floor of the orbit adjacent to and above the maxillary sinus ostium and which if enlarged can significantly constrict the posterior aspect of the ethmoidal infundibulum and ostium of the maxillary sinus above [Kennedy and Zinreich, 1988]. Incidence varies, with Kennedy and Zinreich [1988] mentioning these as encountered in 10% of the population. However, Bolger et al [1991] defined Haller cells as any air cells located beneath the ethmoidal bulla, lamina papyracea, or orbital floor and reported incidence of 45%. The Haller cells consistently open into the middle meatus. This would suggest an anterior ethmoid origin. It is seen distinct from the bulla and the maxillary floor.

II. Large ethmoidal bulla

The ethmoidal bulla can be so extensively pneumatized that it completely fills the sinus of the middle turbinate bone. Enlarged ethmoidal bulla may contribute to sinus disease by obstructing the infundibulum or middle meatus or by being primarily diseased and filled with pus, cysts, or polyps. The exact prevalence of an enlarged ethmoidal bulla is not known.

III. Agger nasi cells

Agger nasi cells, the most constant ethmoidal air cells, lie below the frontal sinus, infero-lateral to the lacrimal sinus, and represent pneumatization of the lacrimal bone by extension of the anterior ethmoidal cell. They are located anterior and superior to the insertion of the middle turbinate bone, along the lateral nasal wall [Stammberger and Wolf, 1988].

Due to their location near the lacrimal sac, involvement of these cells by sinus disease can lead to ocular symptoms. Prevalence has been reported variously from 10% by Schaefer at al [1989] to 98.5% by Bolger et al [1991]. Another study of 110 CT's of the nasal sinus region by Perez-Pinas et al [2000] showed presence of agger nasi cells in all cases, prompting them to disregard it as a variant.

IV. Onodi cells (Sphenoethmoid cells)

These are posterior ethmoid cells that pneumatized far laterally and to the same degree, superiorly to the sphenoid and is intimately associated with the optic nerve. Presence of an Onodi cell may contribute to risk of injury to the optic nerve and internal carotid artery during surgery [Driben et al, 1998]. Prevalence of the Onodi cell has been variously described ranging from 3%-7% [Delano et al, 1996; Weinberger et al, 1996; Driben et al, 1998].

Nasal Septum Variations

I. Nasal septal deviation.

Normally, the structures that make up the nasal septum are aligned to form a straight wall, extending from the cribriform plate superiorly to the hard palate inferiorly. At the junction of the nasal cartilage and vomer, non traumatic acute bowing and deviation of the septum were reported to occur in 20% of the population by Blaugrund SM [1989]. When severe, the deviated septum may compress the middle turbinate bone laterally, narrowing the middle meatus and causing obstruction, secondary inflammation, and infection.

Deviation of the nasal septum may also be found in association with enlarged middle turbinate usually secondary to pneumatization. A strong relationship between the presence of a unilateral or dominant concha and contra-lateral nasal septal deviation while the air channel between the concha and the nasal septum is preserved has been reported by Stallman et al [2004].

Disease affecting the Paranasal Sinuses with manifestations on CT

A) Acute sinusitis
B) Chronic Sinusitis
C) Tumors of the paranasal sinuses
    a) Benign
    b) Malignant

Acute Sinusitis

Acute sinusitis is related to antecedent viral upper respiratory tract infection. Due to mucosal congestion, there is apposition of the mucosal surfaces which leads to obstruction of the normal flow of mucous, resulting in stasis of secretions which create a favorable environment for bacterial super infection.

Imaging findings typically involves the presence of air fluid levels with acute secretions usually showing CT attenuation less than muscle but higher than fat.

Chronic Sinusitis

Most commonly results from repeated episodes of acute or sub-acute disease.

It can also result from a prolonged, progressive or unrelenting disease.

The sinus mucosa reflects a combination of areas of hypertrophic, polypoidal, atrophic and fibrotic changes intermixed with areas of acute inflammation.

Imaging findings usually involve mucosal thickening, polyposis, bone remodeling or bone thickening (due to osteitis from adjacent chronic mucosal inflammation) [Silver et al, 1987].

The characteristic findings of sinus disease include air-fluid levels, mucosal thickening, and opacification of the normally aerated sinus lumen. The single distinguishing feature of acute sinusitis is the air-fluid level as an isolated finding, whereas the only characteristic finding in chronic sinusitis is sclerotic, thickened bone of the sinus wall according to Momeni et al [2007]. Mucosal thickening is common to both acute and chronic sinusitis. The differential diagnosis of sinus wall thickening includes fungal sinusitis (mycetoma), which often coexists with chronic sinusitis.

Fungal sinusitis

Usually seen in poorly controlled diabetics or immunocompromised patients. Aspergillus fumigates is the organism most frequently associated with the diseased state.

Imaging findings include central high attenuation intra sinus mass that is separated from the sinus bony walls by a zone of mucoid attenuation secretion and bone remodeling [Zinreich et al, 1988].

Mucoceles

This term denotes a sinus that remains obstructed and eventually undergoes remodeling of its bony walls so that the sinus cavity is enlarged.

It represents the end stage of a chronically obstructed para nasal sinus. Varghese et al [2004] reported majority of paranasal sinus mucoceles as occurring in the frontal sinus (60%), followed by the ethmoid sinus (30%). Only 10% were localized in the maxillary sinuses, and they are rarely localized to the sphenoid sinus.

Imaging findings include enlarged cavity with remodeling of the walls and mucoid attenuation contents. Concentration of secretions may lead to higher attenuation areas.

Retention cysts and polyps

These are common intra sinus complications of inflammatory sinusitis resulting from obstruction of the ducts of the mucosal serous and / or mucinous glands.

Imaging features usually shows soft tissue attenuation masses involving the nasal cavity and sinuses.

Other complications of sinusitis include

Orbital sequelae of ethmoid or frontal sinus inflammatory disease include involvement by mucoceles, sub periosteal abscesses, orbital phlegmon, venous thrombosis or frank orbital abscesses [Jackson and Kountakis, 2005].

Intracranial inflammatory sequelae including sub dural or epidural abscesses, meningitis, parenchymal abscesses and dural sinus thrombosis [Giannoni et al, 1997].

Osteomyelitis of bones.

Sinonasal neoplasms

Sinonasal neoplasms are rare, comprising less than 1% of all malignancies [Myers et al, 2002]. They represent both diagnostic and therapeutic challenge because the presenting signs and symptoms may be indistinguishable from benign or inflammatory disorders. They typically affect Caucasian males in the fifth to seventh decades of life and have a 2:1 male preponderance.

Tumors of the nasal cavity proper are approximately evenly divided between benign and malignant neoplasia, with inverted papilloma predominating in benign group and squamous cell carcinoma in malignant. On the other hand, most sinus tumors are malignant with squamous cell carcinoma being the most prevalent. The maxillary sinus is the most commonly involved with tumor, followed by the nasal cavity, the ethmoids and the frontal and sphenoid sinuses [Myers et al, 2002].

CT delineates the extent of the tumor extra cranially and intra-cranially.

As a general rule, malignant tumors destroy bone whereas benign processes cause thickening or remodeling of the adjacent bone [Som and Shugar, 1980]. However, all malignant tumors need not destroy bone. Most sino nasal sarcomas remodel abutting bone somewhat, as do most minor salivary gland carcinomas, extramedullary plasmacytomas, lymphomas and hemangiopericytomas.

The true value of CT in these cases is the ability to detect bone erosion. Key areas include the bony orbital walls, cribriform plate, fovea ethmoidalis, posterior wall of the maxillary sinus, pterygopalatine fossa and the sphenoid sinus.

Incidental abnormalities are often noted in the paranasal sinus region even in asymptomatic individuals. This included findings ranging from mucosal thickening or opacification to polyps and benign tumors. Correlations between such incidental findings and presence of various anatomical variants have also been considered. Havaz et al [1988] reported abnormality of one or more paranasal sinuses in approximately 42.5% of asymptomatic cases.

Bolger et al [1991] and Lloyd [1990] also found incidental paranasal mucosal changes in approximately 41.7% and 39% respectively in asymptomatic adults. In a study using plain roentgenograms of the paranasal sinuses, Fascenelli [1969] had found even earlier that approximately 29% of asymptomatic adults demonstrated abnormal findings in their paranasal sinus region X-rays.

The incidence of incidental mucosal changes was found to be even higher in children. Diament et al [1987], in a study involving patients below thirteen years of age, had found approximately 50% incidence of incidental maxillary or ethmoid opacification in the CT of the paranasal sinuses. Another prospective study by Glasier et al [1986] in children having cranial CT for indications unrelated to upper respiratory inflammatory detected incidental paranasal sinus abnormalities in 18% of patients older than one year without signs or symptoms of upper respiratory infection. When signs and /or symptoms of recent upper respiratory tract infection were patient, the incidence of abnormalities was 31%. Considering the high incidence of sinus abnormalities on CT in children with or without evidence of recent upper respiratory infection, the study advised that these abnormalities should not be ascribed to sinusitis without close clinical correlation.

Mucosal thickening was the paranasal sinus abnormality most frequently identified in all studies. Radiologic abnormality was most commonly evident in the ethmoid sinuses (28.4%) followed by the maxillary sinuses (24.8%) [Havaz et al 1988]. No definite correlation could be proved between age, sex or environmental factors of the patient or season in which the scan was performed and only in the sphenoid sinus did a history of allergy significantly improve the chance of mucosal thickening being evident [Havaz et al, 1988].

Havaz et al [1988] also reported that a single sinus group abnormality was most common (56.5%) with both maxillary and ethmoid sinuses showing abnormality together in approximately 33.2%, three sinuses being involved in approximately 10.6% and all four sinuses involved in approximately 2.2% of study population.

Mucosal polyps were most frequently identified in the maxillary sinuses and this was attributed to the relatively large volume of the maxillary antra and so the ease of visualization of the contours of the lining mucosa. Alternatively, chronic inflammation and resulting mucosal hypertrophy may be most common in the maxillary sinuses as a consequence of poor drainage of the antra due to the position of the ostia.

Bone destruction on CT is considered as a reliable indicator of the presence of invasive infective disease or infiltrating malignancy, however, a small percentage of asymptomatic patients (1%) [Havaz et al, 1988] had evidence of bony destruction on CT. Spontaneous dehiscence of the ethmoido-orbital wall and partial volume effect may account for these apparent changes [Teatini et al, 1987]. In view of the fact that bone destruction was reported in an asymptomatic population, it may be recommended that scanning in a second plane, either coronal or sagittal should be done in all cases of reported bone destruction on CT.

Even in symptomatic patients with features of mucosal disease on CT evaluation, some authors including Battacharya et al [1997], Stewart et al [1999] and Krouse [2000] reported that the extent of the mucosal changes did not correlate with the extent of the symptoms.

A review of literature also shows difference of opinion regarding the prevalence of anatomical variants between symptomatic group and an asymptomatic group. In the case of deviation of the nasal septum, while there are not consistent objective criteria to defined a nasal deviation, Calhoun et al [1991] reported an increased prevalence in symptomatic patients (taking >3mm deviation [Lloyd et al, 1991], approximately 19.4% prevalence in control versus approximately 40% in symptomatic patients). Kayalioglu et al [2000] also reported similar conclusions (12% prevalence in control as against approximately 22% in symptomatic patients). However, Jones et al [1997] reported no significant difference in incidence in control and in symptomatic group (approximately 24% in both symptomatic and control group, taking deviation as being lateral to a perpendicular line from the front of the middle turbinate at its attachment to the cribriform). Dua et al [2005] reported deviation of nasal septum in approximately 44% of patients in a study on chronic sinusitis.

Inconsistent results have also been noted regarding the prevalence of other anatomical variants in individuals with rhinosinusitis as compared to their prevalence in asymptomatic individuals. Clerk et al [1989], Calhoun et al [1991] and Sonkens et al [1991] reported a higher prevalence of concha bullosa in symptomatic individuals (approximately 33%, 29% and 29% respectively). However, these reports should be interpreted in light of other studies that show the normal prevalence of concha bullosa is approximately 24%, which is greater than the control groups in these three studies. These studies, including Bolger et al [1991], Jones et al [1997], Willner et al [1997] and Kayalioglu et al [2000] found the prevalence of concha bullosa to be approximately same in both symptomatic and symptomatic groups.

Zinreich [1993] reported approximately 62% incidence of anatomical variants in patients suffering from rhino sinusitis while the percentage was only 11% in the control group. This seemed to suggest a possible correlation or clinical significance of anatomical variants regarding appearance of inflammatory sinus pathology. However, this was contradicted by other studies including Bolger et al [1991] who found the overall incidence to be similar in both these groups. Calhoun et al [1991] compared 100 CT scans carried out to evaluate sinus disease with 82 CT's from a study of orbital pathology and reported the existence of concha bullosa and septal deviation was found to be more in the first group. However, the existence of a paradoxical middle nasal concha was observed equally in both the studies, without association in any case with a sinus anomaly.

In another study by Lloyd [1990], among all the anatomical variants, only concha bullosa was associated with a high incidence of sinusitis (approximately 85%). Presence of anatomical variants were reported in both diseased and symptomatic patients by Stammberger and Wolf [1988] and Bolger et al [1990] and they concluded that the simple presence of variants does not mean a pre disposition to sinus pathology, except when other associated factors are present. However, Yousem [1993] claimed that they may be predisposing factors, depending on their size.

Overall, a critical analysis of the prevalence of the various anatomical variants shows no consistent picture as to the association with disease. Another feature is that the anatomical parameters of women's sinuses show the airways and ostia to be smaller than for men, yet there is no significant difference in the prevalence of disease among the two sexes. Some authors have also reported an increased prevalence of accessory sinus ostia in patients with rhinitis or sinusitis [Jog and Mc Garry, 2003].

RADIOLOGY

Plain X-ray examination

Three views commonly taken in plain x-ray examination are an occipitomental (Waters), an occipitofrontal (Caldwell), and a lateral view to demonstrate the sphenoid sinus. Some departments offer only the occipitomental view as the other views yield little additional information. The place of such films in investigating uncomplicated acute sinusitis is debatable as the findings of air fluid levels or opacity rarely lead to a change in management [Evans, 1994]. In chronic sinusitis the findings are less clear. Air fluid levels are unusual, and a more common finding is mucosal thickening or sinus opacity. The ethmoid sinuses are poorly visualized, and poor correlation exists between the extent of abnormality of the sinus and the severity of the symptoms [Zinreich, 1990].

Computed tomography

Computed tomography is currently the most commonly used modality of radiographic evaluation of paranasal sinuses. CT has evolved continuously and has progressed through several generations of scanner design with helical/ spiral CT scanners now virtually replacing the conventional ones.

The important advantages of spiral CT compared to conventional CT include improved lesion detection, lesion densitometry, optimization of enhancement with intra venous contrast material, reduction of total contrast volume and improved multi planar and three dimensional re constructions [Heiken et al, 1993]. The potential for improved lesion detection with spiral CT is mainly due to two factors: elimination of respiratory misregistration and the ability to reconstruct overlapping images at arbitrary intervals.

Volume acquisition CT involves continuous patient translation during continuous rotation of the source detector assembly [Heiken et al 1993]. As a result, a volume data set is obtained within a short period of time, often within a single breath hold. After acquisition of the raw projection data set, transaxial planar images are generated by means of conventional filtered back projection methods after interpolation of projection data between adjacent turns of spiral path. This results in a data volume that may be viewed as conventional transaxial planar images or with multiplanar and three dimensional methods.

Melhem et al [1996] prescribed an optimal scanning protocol for the paranasal sinuses using a direct coronal plane with a scanning angle not exceeding 10 from the plane perpendicular to the hard palate, 3mm thick contiguous sections, exposure factors of kVp 120, mAs 80, detail reconstruction algorithm, and intermediate window settings (window - + 1700 HU, level =-300HU).

CT scans can provide much more detailed information about the anatomy and abnormalities of the paranasal sinuses than plain films, providing greater definition of the sinuses and is more sensitivity for detecting sinus pathology, especially within the sphenoid and ethmoid sinuses. The primary role of CT scans is to aid in the diagnosis and management of recurrent and chronic sinusitis, or to define the anatomy of the sinuses prior to surgery.

The radiation dose of CT can be lowered using a lower mA protocol [Tack et al, 2003]. CT is superior to MRI for the delineation of the fine bone structures of the infundibular complex, orbital lamina, orbital floor, and cribriform lamina [Hahnel et al, 1999]. Thus, CT is superior to MRI in planning for functional endoscopic sinus surgery (FESS). Coronal CT images are preferred by the surgeons performing FESS as they simulate the appearance of the sinonasal cavity from the perspective of the endoscope [Gotwald et al, 2001].

Bone algorithm may be used to obtain excellent resolution of ostiomeatal complex and other anatomic factors that play a role in sinusitis [Gotwald et al, 2001].

Coronal reformatted images from axial sections may also be helpful, especially when near isotropic voxels are obtained using MDCT scanners. These images may even be as diagnostic as images acquired in the direct coronal plane and may even be preferable to direct coronal images in cases with dental work artifacts, limited patient mobility, and to decrease radiation exposure [Takahashi et al, 2007].

Computed tomography should ideally be requested only after failure of medical treatment, if a complication arises, or if malignancy is suspected. Computed tomography not only identifies soft tissue abnormalities but provides a surgical map of the paranasal sinuses and thus plays an invaluable role in defining the bony anatomy when surgery is planned [Mason et al, 1998]. Anatomical variations are identified which would not be seen on endoscopic examination of the nose but which may compromise the ostiomeatal complex. Computed tomography has permitted a more widespread acceptance of functional endoscopic sinus surgery, which has radically changed the surgical approach to inflammatory sinus disease.

Magnetic resonance imaging

Magnetic resonance imaging provides high definition scans of sections of soft tissue without ionizing radiation, but it cannot demonstrate bone. Its role in sinus disease has been reviewed [Shapiro and Som, 1989]. The mucosa of the ethmoid sinuses and nasal cavity have a natural cycle of vasodilatation and mucosal edema followed by vasoconstriction and mucosal shrinkage, and magnetic resonance imaging is therefore of limited value in investigating chronic sinusitis, which is secondary to disease of the anterior ethmoids.

The signal intensity of normal mucosa in this region in its edematous phase of the nasal cycle is indistinguishable from that of extensive inflammatory disease. The frontal, maxillary, and sphenoid sinuses do not have such a physiological cycle, and magnetic resonance imaging can be helpful.

Certain disease processes may be differentiated by magnetic resonance imaging. Inflammatory conditions exhibit high signal intensity on T2 weighted images, whereas neoplastic processes, of which 90% are squamous cell carcinoma, assume an intermediate bright signal on T2 weighted images [Som et al, 1988]. Fungal concretions have low signal intensities on T2 weighted images, similar to air.

Although CT is superior to MRI in the preoperative planning of FESS [Hahnel et al, 1999], MRI may be used as a primary diagnostic instrument in screening for foci of septic disease before implantation of organs or prostheses, in the diagnosis of complications of sinus infection or FESS, and to assess therapeutic success. Therefore, MRI is an alternative to CT in the evaluation of the paranasal sinuses, with its main limitations being a decreased ability to delineate bone detail and its higher cost [Sonkens et al, 1991].

AIMS AND OBJECTIVES

Evaluation of the paranasal sinuses in asymptomatic population to detect incidental CT findings.

MATERIAL AND METHODS

This study is a prospective study in the Department of Radiodiagnosis, CMC Ludhiana from August 2007 to September 2008. Patients included in this study were those patients who were getting investigated by computed tomography for non sinus indications in whom the paranasal sinus region could be included in the field of study. An exclusion criteria was maintained to ensure that these patients did not have any symptoms of sinus disease or any relevant history suggestive of predisposition to sinus disease.

Patients who had a history of any of the following symptoms were excluded from the asymptomatic group:-

1. Recurrent or chronic headache. 2. Facial pain 3. Nasal drainage (anterior rhinorrhea or post nasal drip) 4. Nasal congestion 5. Dysosmia 6. Chronic low grade fever.

We also excluded all patients who were being investigated for trauma, patients who gave history of recent or old trauma near the region of the paranasal sinuses and also all patients in altered sensorium who were unable to provide a reliable history for the symptoms mentioned above.

All the scans were done on the GE spiral (Helical) HISPEED FX/i CT scanner which is in use in our hospital.

The results were duly tabulated and analyzed using statistical techniques such as Chi-square test of independence, Chi-square test of Goodness of fit and Confidence Interval.

RESULSTS AND ANALYSIS

A total of 229 patients were included in this study. All these patients were asymptomatic for paranasal sinus disease.

Table 1

DISTRIBUTION OF PATIENTS ACCORDING TO SEX

Sex	Paranasal sinus finding present	Normal paranasal sinus	Total
Male	86	76	162
Female	33	34	67

Among the patients who were included in the study group [Table 1], 162 out of 229 were males (70.7%) and the remaining were females (29.3%). The male: female ratio was 2.4:1. Mucosal thickening or secretions were present in 86out of the 162 male (53%) and in 33out of the 67 female patients (49.2%) who were included in the study.

Table 2

DISTRIBUTION OF PATIENTS ACCORDING TO AGE GROUPS

Age groups	Number of patients
≤ 20 Years	11 (4.8%)
21-40Years	97 (42.4%)
41 -60 Years	75 (32.8%)
≥ 61- 80 Years	46 (20.0%)

Young adults between the age of 21-40 Years comprised majority of the study group [**Table 2.**] with 97 out of 229 patients (42.3%) falling in this category. Patients in the age group of 41-60 years contributed 32.7% of the study group. There were 46 patients who were in the 61 Years and above age group. Pediatric patients were excluded from the study group as part of the exclusion criteria.

TABLE. 3

DISTRIBUTION OF INCIDENTAL PARANASAL SINUS FINDINGS

ACCORDING TO THE AGE GROUPS

Age groups	Patients with incidental paranasal sinus findings	Patients with normal paranasal sinuses	Percentage of incidental paranasal sinus findings
≤ 20 Years	5	6	45.0%
21-40 Years	43	54	44.3%
41-60 Years	40	35	53.3%
≥ 61 Years	31	15	67.4%

The age group comprising 61 or above years of age was found to have a greater incidence of mucosal thickening, polyps or secretions as compared to the rest of the age groups [**Table.3**]. 31 patients out of the 46 patients in this group had incidental findings (67.4%). The middle age group (41-60 Years) had 40 patients with incidental sinus findings out of a total of 75 patients (53.3%) The group from 21 to 40Years of age, which comprised the maximum distribution of patients, had the least number of incidental paranasal sinus findings (44.3%).

Table. 4

INCIDENCE OF PARANASAL SINUS FINDING IN THE PRESENCE OF COEXISTING DIABETES

Coexisting Diabetes	Patients with incidental sinus findings	Patients with normal sinuses	Total
Present	47	14	61
Absent	72	96	168

Chi-square value = 20.95

P value =0.0000047

Co-existing Diabetes	Patients with incidental sinus	P estimate	Standard Error	95% Confidence Interval

	finding			
61	47	0.77	0.054	0.66-0.88

Out of the 229 patients in the study, 61 patients were diagnosed diabetics [**Table.4**]. Among these patients, 47 patients (77%) had incidental sinus secretions or mucosal thickening. Only 14 patients (23%) with diabetes did not have any incidental sinus finding. This gave a strong association between diabetes and presence of incidental sinus secretions or mucosal thickening (p value- 0.0000047). People with diabetes therefore have a high chance of demonstrating incidental sinus findings even in the absence of symptomatic disease.

TABLE. 5

INCIDENTAL SINUS FINDINGS IN HYPERTENSIVES

	Sinus Findings Present	No Abnormal Sinus Findings Present	Total
Hypertension	21	16	37
Not hypertensive	98	94	192

Chi Square: 0.406

P Value :0.52

Altogether, 37 patients out of the 229 were diagnosed hypertension [**Table.5**]. 21 out of them had incidental findings in their paranasal sinuses (56.8%) whereas the remaining 16 patients did not demonstrate any evidence of paranasal sinus abnormality (43.2%). No significant association was demonstrable between presence of hypertension and predisposition to incidental sinus findings (p value 0.52).

TABLE. 6

INCIDENCE OF ANATOMICAL VARIANTS AND THEIR 95%

CONFIDENCE INTERVAL (n=229)

VARIANT	INCIDENCE (n=229)	ESTIMATED PROPORTION	95% CONFIDENCE INTERVAL	STANDARD ERROR
Aggar nasi	190	0.84	0.790-0.896	0.0243
DNS	81	0.35	0.292-0.416	0.315
Concha Bullosa	90	0.39	0.3297-0.456	0.0322
Haller Cells	27	0.11	0.0724-0.1546	0.0209
Onodi cells	28	0.12	0.076-0.1596	0.0213
Paradoxical middle turbinate	9	0.0349	0.0112-0.0587	0.0121
Prominent ethmoid bulla	10	0.0437	0.0172-0.0701	0.0135
Vomeral pneumatisation	3	0.013	0-0.0278	0.0075
Inferior				

turbinate hypertrophy	3	0.013	0-0.278	0.0075
Sinus Turbinate	1	0.00437	0-0.0129	0.00436
Hypoplastic frontal sinus	1	0.00437	0-0.0129	0.00436

Presence of anatomical variants was noted in many of the patients [**Table. 6**], with agger nasi noted in 190 out of 229 patients (82.9%). This gave a high confidence interval of 0.79-0.89 and was therefore excluded from being considered as a variant in the rest of this study. Excluding the presence of agger nasi, 161 out of 229 patients demonstrated the presence of at least one anatomical variant (70.3%).

Concha bullosa was present in 90 out of 229 patients (39.3%) and was the most common anatomical variant after excluding agger nasi. 53 patients out of 229 had unilateral concha bullosa (23.1%) while 37 patients had bilateral concha bullosa (16.2%).

Deviation of the nasal septum was the next most common variant and was seen in 81 out of 229 patients (35.4%).

Halle cells and Onodi cells were seen in 27 and 28 patients respectively giving an almost equal incidence of 11.8% for Haller cells and 12.2% for Onodi cells.

20 of the patients out of the total study group of 229 demonstrated unilateral Haller cells (8.7%) while the remaining 7 were bilateral (3.1%).

Unilateral Onodi cells were noted in 22 patients (9.6%) while 6 patients out of 229 had bilateral involvement (2.6%).

Other variants which were seen included prominent ethmoid bulla (4.4%) paradoxical middle turbinate (3.9%), pneumatisation of the vomeral bone (1.3%), hypertrophied inferior turbinate (1.3%) and sinus turbinate and hypoplastic frontal sinuses (0.4).

TABLE. 7

INCIDENCE OF THE VARIOUS TYPE OF CONCHA BULLOSA

TYPE OF CONCHA BULLOSA	NUMBER OF PATIENT (n=90)	P ESTIMATE	Standard Error	95% Confidence interval
Lamellar	35	0.39	0.051	0.29-0.49
Extensive	30	0.33	0.049	0.24-0.43
Bulbous	25	0.28	0.047	0.19-0.37

90 patients demonstrated presence of concha bullosa in the paranasal sinuses [**Table.7**]. Out of them, lamellar variety was the one most commonly seen with 35 patients out of 90 (38.9%) demonstrating this variety of concha bullosa. Extensive (true) variety was the next most common and was seen in 30 patients (33.3%). Bulbous variety of concha bullosa was seen in 25 patients out of 229 (27.8%).

TABLE. 8

TYPES OF DEVIATOIN OF THE NASAL SEPTUM

Type of DNS	Number (n=81)	P Estimate	Standard Error	95% Confidence Interval

DNS to the left side	34	0.42	0.055	0.31-0.53
DNS to the right side	27	0.33	0.52	0.23-0.44
S shaped septum	12	0.15	0.039	0.071-0.23
Nasal spur	8	0.10	0.033	0.034-0.16

Deviation of the nasal septum was seen in 81 out of 229 patients [**Table. 8**]. Among these patients, 34 patients out of 81 showed deviation to the left side (1.9%), 27 patients had deviation of the nasal septum to the right side (33.3%), 12 had an S shaped septum (14.9%) and the remaining 8 scans showed nasal spur without a broad based deviation of the septum (9.9%).

TABLE. 9

ASSOCIATION BETWEEN THE PRESENCE OF CONCHA BULLOSA AND DEVIATOIN OF THE NASAL SEPTUM

DNS	**Concha Bullosa**		**Total Incidence**
	Present	**Absent**	
Present	37	44	81
Absent	53	95	148
Total	90	139	229

Chi- square value = 2.13

P value =0.14

Deviation of the nasal septum was noted in 81 patients (35.4%) while concha bullosa was noted in 90 patients (39.3%) [**Table.9**]. 37 out of these patients demonstrated concomitant concha bullosa and deviated nasal septum. However, no significant association could be demonstrated between presence of concha bullosa and deviation of the nasal septum (p value – 0.14). Therefore presence of concha bullosa cannot be said to be a predisposing factor for deviation of the nasal septum.

TABLE. 10

ASSOCIATION BETWEEN CONCHA BULLOSA AND CONTRALATERAL DEVIATION OF THE NASAL SEPTUM WHEN CO-EXISTANT (n=37)

Unilateral concha bullosa/Bilateral with unilateral dominance	**Deviated nasal septum (DNS)**	**P estimate**	**Standard Error**	**95% Confidence Interval**
Contralateral side to DNS	32	0.86	0.056	.80-.97
Ipsilateral side to DNS	5	0.14	0.056	.03-.20

Co-existence of deviated nasal septum and concha bullosa was noted in 37 patients [**Table.10**]. Out of these, 32 patients demonstrated either a unilateral concha bullosa on the side opposite to the side to which the nasal septum was deviated or had bilateral concha bullosa with the dominant one on the side opposite to the side to which the nasal septum was deviated. This corresponded to 86.5% of the patients with co-existing concha bullosa and deviated nasal septum. This suggested that when the two are co existent, there is high probability (0.97) for the septal deviation to be opposite to the side of the unilateral/ dominant concha bullosa.

TABLE .11

PARANASAL SINUS ABNORMALITY SEEN IN THE STUDY

Sinus Abnormality	Incidence (N=229)	P Estimate	Confidence Interval	Standard Error
Mucosal thickening alone	46	.20	.1490-.2523	.0265
Mucosal thickening+secretions	46	.20	.1490-.2523	.0265
Secretions alone	27	.118	.076161-.1596	.0213
Mucosal polyps	7	.031	.0083-.053	.0114

119 patients out of the 229 showed presence of incidental mucosal thickening, secretions or polyps corresponding to approximately 51.9% [**Table. 11**]. Mucosal thickening was the most common abnormal paranasal sinus pattern seen and was seen in 92 patients out of the 229 patients in the study group (40.1%).

Out of the 92 patients with mucosal thickening, secretions were also present in one or more of the remaining sinuses in 46 patients (50%), whereas the remaining 46 had only mucosal thickening.

Altogether, secretions were identified in 73 patients out of the 229 patients in the study group (31.9%). Out of these, 27 patients demonstrated only secretions (37%) while the remaining 46 patients (63%) also had mucosal thickening in one or more of the other sinuses.

Mucosal polyps were noted in 7 patients out of the 229 patients in the study group (3.0%).

TABLE. 12

DISTRIBUTION OF SINUS INVOLVEMENT

Sinus Involved	Incidence (N=229)	P Estimate	Confidence Interval	Standard Error
Ethmoid sinuses	84	.367	.304-.429	.0318
Maxillary sinus	51	.222	.168-.276	.0274
Sphenoid sinus	45	.196	.145-.248	.0263
Frontal sinus	13	.056	.0267-.0867	.0153

Among the 229 patients, 84 patients demonstrated incidental secretions or mucosal thickening in their ethmoid sinuses (36.7%) [**Table.12**]. the maxillary sinuses were the next most affected with 51 patients showing maxillary findings (22.3%). The sphenoid sinuses were involved in 45 (19.6%) and the frontal sinuses in 13 (5.7%) patients respectively.

TABLE. 13

PATTERN OF SINUS INVOLVEMENT

Pattern of involvement	Incidence (N=229)	P Estimate	Standard Error	95% Confidence Interval
Single sinus group	50	0.22	0.027	0.165-0.272
Two sinus groups	50	0.22	0.027	0.165-0.272
3 or more sinus groups	19	0.083	0.018	0.047-0.119

Among the 229 patients who had incidental mucosal thickening or secretion in their paranasal sinuses [**Table. 13**], involvement of a single sinus group was noted in 50patients (21.8%). An equal number of patients also demonstrated simultaneous involvement of two sinuses (21.8%). Three or more sinus groups were involved in 19 patients (8.3%).

TABLE. 14

DENSITY OF THE INCIDENTAL SINUS SECRETIONS

Density	**Number of Patients (N=73)**	**P estimated**	**Standard Error**	**95% Confidence Interval**
Fluid	66	0.90	0.034	0.84-0.97
Hyperdense	4	0.055	0.027	0.0026-0.11
Calcifications	4	0.055	0.027	0.0026-0.11
Soft tissue	1	0.014	0.0136	0-0.040

73 of the patients demonstrated incidental sinus secretions [**Table.14**]. Fluid density was noted in 66 out of these 73 patients (90.4%) with hyperdense secretions seen in 4 patients out of this 73 (5.5%). Calcifications were noted is seen in 4 patients (5.5%) and soft tissue density was seen in 1 patient (1.4%) respectively. Out of these 73 patients, 3 patients demonstrated more than one density pattern due to involvement of multiple sinuses.

TABLE. 15

DISTRIBUTION OF SINONASAL POLYPOSIS

Density	Number of patients (N=7)	P estimate	Standard Error	95% Confidence Interval
Maxillary	5	0.71	0.17	0.38-0.99
Ethmoid	1	0.14	0.13	0-0.40
Sphenoid	1	0.14	0.13	0-0.40
Frontal	--			--

7 patients out of 229 (3.0%) demonstrated presence of sinonasal polyposis [**Table.15**]. 5 of these patients had involvement of the maxillary sinuses with the ethmoid and the sphenoid sinuses being the involved group in 1 patient each.

TABLE. 16

ASSOCIATION OF ANATOMICAL VARIANTS AND INCIDENTAL PARANASAL SINUS FINDINGS

PARANASAL SINUSES	ANATOMICAL VARIANTS	
	PRESENT	ABSENT
Normal	80	30
Abnormal	81	38

Chi square = 0.9952 NS

P value = 0.3185

Among the 229 patients, 119 demonstrated incidental sinus secretion or mucosal thickening [**Table.16**]. Out of these 119 patients, 81 patients also demonstrated presence of anatomical variants other than agger nasi (68.1%). The remaining 38 patients did not have presence of anatomical variants. However, no significant association could be demonstrated between these attributes (p value 0.3185) to suggest that presence of anatomical variants predisposes to incidental sinus abnormalities.

TABLE. 17

ASSOCIATION BETWEEN PRESENCE OF DEVIATED NASAL SEPTUM AND CONCHA BULLOSA AND THE PRESENCE OF INCIDENTAL SINUS FINDINGS

PARANASAL SINUS	DNS	CONCHA BULLOSA	DNS+CONCHA BULLOSA
Incidental findings	43	46	20
Normal	38	44	17

Chi square = .9145 NS
P= .6330

Among the anatomical variants, deviated nasal septum and concha bullosa were the most commonly found. Out of the 81 patients with deviation of the nasal septum, 43 patients had incidental sinus secretion or mucosal thickening (53%) while 38 patients did not have associated sinus findings (47%). [**Table.17**].

Among the 90 patients who had concha bullosa, incidental sinus secretion or mucosal thickening was seen in 46 (51.1%) while the remaining 44 patients (48.9%) did not have incidental sinus findings.

Concha bullosa and deviation of the nasal septum were no existing in 37 patients. 20 of these (54%) had incidental sinus findings while the remaining 17 scans (46%) did not have any sinus findings.

Despite concha bullosa and deviation of the nasal septum being the most common of the anatomical variants in the study, no significant association could be demonstrated between presence of these variants and incidental sinus abnormalities, even in those patients in whom there was co-existence of concha bullosa and deviated nasal septum. (p value 0.6330). So presence of concha bullosa or deviated nasal septum, even when co existent, cannot be considered to predispose to incidental sinus secretions or mucosal thickening.

TABLE. 18

ASSOCIATION BETWEEN NASAL SEPTAL DEVIATION AND IPSILATERAL INCIDENTAL SINUS ABNORMALITY

	DEVIATION OF NASAL SEPTUM (n=81)		
	IPSILATERAL DEVIATION	CONTRALATERAL DEVIATION	"S" SHAPED SEPTUM
INCIDENTAL	31	4	8

PARANASAL SINUS ABNORMALITY			
P estimate	0.72	0.093	0.19
Standard Error	0.068	0.044	0.059
95% Confidence Interval	0.59-0.85	0.062-0.18	0.069-0.30

Among the patients who demonstrated deviation of the nasal septum [**Table.18**] along with co-existing incidental sinus secretions or mucosal thickening (43 out of 229 patients), 31 patients demonstrated incidental sinus abnormality on the side ipsilateral to the side of nasal septal deviation (72.1%). 8 patients demonstrated an "S" shaped septum (18.6%) and only 4 patients had sinus findings on the contra lateral side to the septal deviation (9.4%). This showed a high probability that in patients with deviated nasal septum, when sinus abnormalities are present, they tend to be ipsilateral to the side of septal deviation.

TABLE. 18.

STATISTICAL COMPARISON BETWEEN OUR STUDY AND OTHER STUDIES WHICH EVALUATED INCIDENTAL PARANASAL SINUS FINDINGS IN ASYMPTOMATIC PATIENTS

Study	Percentage (%) of incidental sinus abnormalities
Out study	51.9
Lloyd [1991]	30
Havas [1988]	42.5
Bolger [1991]	41.7

Chi-square value = 5.81

P value =0.12

Statistically, there was no significant difference in the incidence of paranasal sinus abnormality in asymptomatic patients when comparing our study against the other similar studies (p value- 0.12) done abroad.

DISCUSSION

A total of 229 patients were included over the period of the study after the application of the exclusion criteria. All of them had undergone their CT scan in our department.

Among the patients who were included in the study group, 162 out of 229 were males (70.7%) and the remaining were females (29.3%).

Young adults between the age of 21-40 Years comprised majority of the study group with 97 out of 229 patients (42.3%) falling in this category. However, in terms of incidental sinus findings, the age group equaling or more than 61 years had the maximum percentage of abnormal scans (68.2%).

In this study, 61 patients out of the 229 in the study group were diagnosed cases of diabetes. 47 patients among these (77%) had incidental sinus secretions or mucosal thickening. 14 patients (23%) with diabetes did not have any incidental sinus finding. This showed a significant association between presence of diabetes and incidental sinus secretion or mucosal thickening (p value – 0.0000047). Diabetics therefore have a high chance of demonstrating incidental sinus abnormality even in the absence of symptomatic disease.

However, no significant association could be demonstrated between presence of hypertension and predisposition to incidental sinus disease. Among the 37 patients who were diagnosed hypertension, only 21 patients had incidental findings as against 16 patients with normal paranasal sinuses. This gave p value of 0.52 which showed that hypertension does not predispose to presence of incidental sinus abnormality.

Agger nasi was found to be present in a total of 190 out of 229 patients, which corresponded to approximately 82.9% of the study population. This was less than the percentage quoted by Bolger et al [1991], Jones et al [1997] and Nitinavankarn et al [2005] who had reported agger nasi in in 98.5%, 96% and 92% respectively in their studies. However, it was corresponding to the percentage found by Maru and Gupta [2001] who observed agger nasi in 88.5% of their study population. Schaefere et al [1989] had reported them as being seen in as low as 10% of the study group while Dua et al [2005] had reported agger nasi in 40% of the study group in a stud on patients with chronic sinusitis. The high percentage of observation in our study gave a confidence interval of 0.79-0.89 and therefore agger nasi was excluded from being considered as a variant in the rest of this study.

Excluding the presence of agger nasi, a total of 161 out of 229 patients demonstrated at least one anatomical variant in this study (70.3%). This was comparable to Perez-Pinas et al [2000] who had reported anatomical variants as being seen in 67% of population even after excluding agger nasi.

Concha bullosa was found to be the next most common variant with 90 out of the 229 patients having unilateral or bilateral concha bullosa, which corresponded to 39.3% of the study population. This was found to be more than that by Jones et al [1997] who had reported concha bullosa in 23% of their study group. However, it was less than Bolger et al [1991] who reported concha bullosa in 50% of their control group. Perez-Pinas et al [2000] had reported concha bullosa in 24.5% of the study group with Nitinavankarn et al [2005] and Kayalioglu et al [2000] reporting them as being present in 34.1% and 26.8% of the study group respectively.

Out of the 229 patients, 53 had unilateral concha bullosa (23.1%) while 37 patients had bilateral concha bullosa (16.2%). Nitinavankarn et al [2005] had observed unilateral and bilateral concha bullosa as being seen in 30.7% and 19.3% of the population respectively in their study.

Out of the three types of concha bullosa, lamellar variety was seen in 39%, extensive variety in 34% and bulbous variety in 27% of the patients with concha bullosa. Nitinavankarn et al [2005] had also observed lamellar variety to be the most common (56.6%) followed by extensive variety (36.7%) and bulbous variety (6.7%).

Deviation of the nasal septum was the next most common variant and was seen in 81 out of 229 patients, corresponding to 35.4%. Jones et al [1997] had got a lower percentage (24%0 while it was the most common variant found by Dua et al [2005] in their study on chronic sinusitis and was noted in 44% of the patient. Perez-Pinas et al [2000] had observed deviation of the nasal septum in 58% of their study group while Kayalioglu et al [2000] reported deviated nasal septum in 12% of their control group.

Among the 81 patients with deviated nasal septum, 34 patients showed deviation to the left side (41.9%), 27 patients showed deviation of the septum to the right side (33.3%). 12 had an S shaped septum (14.9%) and the remaining 8 patients demonstrated nasal spur without a broad basal septal deviation (9.9%). Earwaker [1993] had reported deviation of the nasal septum in 44% of the study population with 21% of these patients demonstrating an S shaped septum and 7.3% showing nasal spur without a broad based deviation of the septum.

Haller cells and Onodi cells were found in almost similar number of patients in this study. Haller cells were found in 27 out of 229 patients, giving a percentage of 11.8%. This was corresponding to the observations of 12% reported by Jones et al [1997] and 16% by Dua et al [2005] while Nitinavankarn et al [2005] had observed Haller cells in 24% of the study population. On the other hand, Bolger et al [1991] had reported them in 42% in the control group in their study and Perez-Pinas et al [2000] had also reported Haller cells in 45% of the study population.

Out of the 27 patients who had Haller cells, 20 patients demonstrated unilateral Haller cells (74%) while the remaining 7 were bilateral (26%).

Onodi cells were found in 28 out of 229 patients, giving a percentage of 12.2% Jones et al [1997] had reported them as being seen in 9% of their study group while Perez-Pinas et al [2000] and Dua et al [2005] reported them as being present in 10.9% and 6% respectively of their study groups.

Out of the 28 patients with Onodi cells, 22 patients showed unilateral involvement (78.6%) while the remaining 6 had bilateral involvement (21.4%).

Other variants which were seen in this study included paradoxical middle turbinate which was noted in 9 patients out of 229, giving a percentage of 3.9%. This was lower than what had been reported in other studies including Bolger et al [1991] who observed them in 22.3% of their patients, Jones et al [1997] who reported them in 16% of the study population and Calhoun et al [1991] who reported them as being present in 12% of the study group. Peez-Pinas et al [2000] had observed them in 10% of the study group and Kayalioglu et al [2000] had reported them in 7.3% of their patients.

Prominent ethmoid bulla was noted in a total of 10 out of 229 patients (4.4%). Jones et al [1997] had reported them in 7% of their control group.

Pneumatisation of the vomeral bone and hypertrophy of the inferior turbinate were seen in 3 out of 229 patients (1.3%).

Sinus turbinate and hypoplastic frontal sinus were seen in 1 each out of the total 229 patients (0.4%).

Out of the 229 patients in the study, 37 patients had co-existing concha bullosa and nasal septum deviation (16.2%) while 44 patients had deviation of the nasal septum without the presence of concha bullosa (19.2%). Presence of concha bullosa without a concomitant deviated nasal septum was noted in 53 patients (23.1%). No significant relationship could be demonstrated between the presence of concha bullosa and deviated nasal septum (p value 0.548). This showed that presence of concha bullosa could not be considered as predisposing to deviation of the nasal septum. Bhandhary and Kamath [2009] had also concluded that concha bullosa had no role to play in etiology of nasal septal deviation by observing the presence of air column separating the two entities in those patients where they were co existent.

However, in those patients where deviated nasal septum and concha bullosa were co-exiting, we found a strong association between presence of concha bullosa (either unilateral or bilateral concha bullosa with uni sided dominance) and deviation of the nasal septal convexity away from the concha.

Co-existence of deviated nasal septum and concha bullosa was noted in 37 patients out of the 229 patients in the study group. Out of these 37 patients, 32 patients demonstrated either unilateral concha bullosa on the contra lateral side to the deviation or bilateral concha bullosa with the dominant one on the opposite side. This corresponded to an incidence of approximately 86.5%. Only 5 scans had unilateral or dominant bilateral concha bullosa ipsilateral to the side of deviated nasal septum. This showed a high probability of 0.97 for deviation of the nasal septal convexity to be away from the side of the unilateral/ dominant concha bullosa in patients in whom they were co-existent. Similar conclusions has also been demonstrated by Stallman et al [2004] in a study on 998 patients who had paranasal sinus CT study.

Incidental mucosal thickening, secretions or polyps were found in 119 out of the total 229 patients in this study, corresponding to approximately 51.9%.

This was higher than Lloyd et al [1991] who had found incidental sinus findings in 30% of the study group or Havaz et al [1988] who observed them in 42.5% of their study group. However, statistically, there was no significant difference between incidental paranasal sinus findings in asymptomatic patients on comparing these studies with our study (p value 0.12). This showed that our findings were statistically similar to these studies which had been done in other countries.

Mucosal thickening was the most common abnormal pattern seen in the patients who had incidental findings in the paranasal sinuses in this study and was noted in 92 out of 229 patients (40.1%). Havaz et al [1988] had also reported mucosal thickening to be the most common incidental finding in the paranasal sinuses.

Secretions were identified in 73 out of the 229 patients (31.9%). Among these, 46 patients also demonstrated mucosal thickening in one or more of the other sinuses (20.1%) while the remaining 27 patients (11.8%) demonstrated only secretions. As regards the 73 patients who demonstrated secretions, fluid density was noted in 66 patients (90.4%), with hyperdense secretions, calcifications and soft tissue density seen in 4 (5.5%), 4(5.5%) and 1(1.4%) patient respectively. Out of these, 3 patients demonstrated more than one density pattern due to involvement of multiple sinuses.

Mucosal polyps were noted in 7 patients out of the 229 (3.0%). This was lower than Havaz et al [1988] who had reported polyps in 7.4% of their study group. In our study, 5 patients out of these 7 had polyps involving the maxillary sinuses (71.4%), 1 patient had involvement of the ethmoid and one had involvement of the sphenoid sinus. This distribution pattern of significantly increased incidence in the maxillary sinuses had also been noted by Havaz et al [1988] who had reported 79.6% of the incidental polyps in his study as being present in the maxillary sinus.

Presence of bone thickening was noted in 6 patients out of the 229, giving a percentage of 2.6%, while bone erosions were noted in 4 out of 229 patients (1.7%). All of these cases had either mucosal thickening or polyps associated with these sinuses. However, scanning in a second plane was not done for these patients and so the presence of partial volume averaging could not be ruled out.

In terms of distribution, the ethmoid sinuses were found to be the most commonly affected among the patients who demonstrated mucosal thickening or secretions. This pattern corresponded to both Havaz et al [1988] and Lloyd et al [1991].

The ethmoid sinuses were found to be involved in 84 out of the 229 patients (36.7%). The maxillary sinuses were the next most affected with 51 patients showing maxillary findings (22.3%). The sphenoid sinuses were involved in 45 patients (19.6%) and the frontal sinuses in 13 (5.7%). The distribution as reported by Havaz et al [1988] was ethmoid sinuses (28.4%), maxillary sinuses (24.8%), sphenoid sinuses (9.5%) and frontal sinuses (4.6%) in descending order of involvement.

The pattern of involvement showed abnormality in a single sinus group in 50 of the 229 patients (21.8%), however, an equal incidence was also noted for simultaneous involvement of two sinuses (21.8%). Three or more sinus groups were involved in 19 patients (8.3%). Havaz et al [1988] had demonstrated involvement of a single sinus group to be the most common pattern (56.5% of abnormal scans) followed by simultaneous involvement of two groups of sinuses (27.6%) with three or more groups being involved in 15.9% of the patients who had demonstrated incidental sinus findings on CT.

Maxillary and ethmoid sinuses were the two most commonly affected sinuses and between them accounted for 72.2% of the abnormal sinuses in the study.

Incidental sinus secretion, mucosal thickening of polyposis was seen in 119 out of the 229 patients. Among these patients, 81 of them also demonstrated presence of anatomical variants other than agger nasi (68.1%) while 38 patients did not have associated variants (31.9%). However, significant correlation could not be obtained between presence of anatomical variant and presence of sinus secretion or mucosal thickening as p value was 0.3185. This was going in favour of studies like Stammberger and Wolf [1988] and Bolger et al [1990] who has also suggested that the mere presence of anatomical variants does not predispose to sinus pathology. In our study also, we found that presence of anatomical variants were not predisposing to presence of incidental sinus findings.

Among the patients having incidental sinus secretions or mucosal thickening along with co-existing anatomical variants, deviated nasal septum and concha bullosa were the variants most commonly found.

Deviation of the nasal septum was seen in 81 out of the 229 patients. Out of these 81 patients, 43 patients had presence of incidental sinus secretion or mucosal thickening (53%) while 38 patients did not have associated sinus findings (47%). No significant correlation was present to suggest that the presence of a deviated nasal septum predisposes to incidental sinus findings. This was similar to the results of Stallman et al [2004].

Concha bullosa was seen in 90 out of 229 patients, 46 patients out of this 90 demonstrated incidental sinus secretion or mucosal thickening (51.1%) while the remaining 44 patients (48.9%) did not have incidental sinus findings. Again, no significant correlation could be derived to suggest that presence of concha bullosa predisposes to incidental sinus findings. On the other hand, Lloyd [1990] and Calhoun et al [1991] had suggested that presence of concha bullosa predisposes to sinus pathology. Bhandary and Kamath [2009] had also suggested that presence of concha bullosa predisposes to sinus disease.

Even in the patients in whom both concha bullosa and deviated nasal septum were found to be co existent (37 out of 229 patients), there was no significant predisposition to incidental sinus findings, 20 patients out of this 37 had incidental sinus findings (54%) while the remaining 17 patients (46%) did not have any sinus findings. This gave p-value of 0.6330, showing that even in patients in whom both deviated nasal septum and concha bullosa are co-existing, there is still no evidence to definitely suggest predisposition to sinus secretions, mucosal thickening or polyps.

However, among the patients with deviated nasal septum who had co existing incidental sinus findings (43 patients out of 229); we found a high probability for the affected sinuses to be ipsilateral to the side of septal deviation. Among the 43 patients who demonstrated presence of both deviated nasal septum and incidental sinus findings, 31 patients had sinus findings ipsilateral to the deviated septum (72.1%) while 8 patients had an “S” shaped septum (18.6%) and only 4 patients had sinus findings on the contra lateral side to the septal deviation (9.4%). This gave significant association showing that in patients with deviated nasal septum who have incidental sinus findings, there is high probability that the sinus groups which are affected will be ipsilateral to the side of the septal convexity.

SUMMARY AND CONCLUSIONS

1. The aim of the study was to evaluate the incidental CT findings in the paranasal sinuses in asymptomatic population.

2. A total of 229 patients were included in the study group over a period of one year. All of them had CT evaluation done for non-sinus related indications. An exclusion criteria was maintained to exclude patients who had symptoms suggestive of paranasal sinus disease or in whom reliable history could not be obtained.

3. All the patients had their CT scans done in the 64 slice helical CT scanner which is in our department.

4. The bulk of the patients who were included in the study group turned out to be males ((70%) and the commonest age group was 21-40Years (42.3%). Patients in the 61years of age or more groups, however, had the most number of incidental findings (68.2%).

5. A significant association was noted between presence of diabetes and predisposition to incidental findings in the paranasal sinus region (p value – 0.000047).

6. Agger nasi was seen in approximately 82.9% of the study population, giving confidence levels of 0.79-0.89 and was excluded from being considered as an anatomical variant.

7. Even after excluding agger nasi, 161 patients demonstrated at least one anatomical variant (70.3%).

8. Concha bullosa was noted in 90 out of the 229 patients, and was the commonest variant after excluding agger nasi (39.3%). Unilateral concha bullosa was seen in 53 patients out of 229 (23.1%) and bilateral concha bullosa was seen in 37 patients (16.2%). Lamellar variety was the commonest type of concha bullosa and constituted 39% of concha bullosa while extensive variety and bulbous variety were noted in 34% and 17% respectively.

9. Deviation of the nasal septum was seen in 81 out of the 229 patients (35.4%). A broad based septal deviation to the left side was seen in 34 patients (41.9%) while 27 patients had a septal deviation towards the right side (33.3%). An S shaped septum was seen in 12 patients (14.8%) and a nasal spur without a broad based septal deviation was noted in 8 patients (9.8%).

10. Haller cells and Onodi cells were seen in 27 patients out of 229 (11.8%) and 28 patients out of 229 respectively (12.2%). Unilateral involvement was more common in both these variants with 74% of the patients with Haller cells and 78.6% of the patients with Onodi cells having unilateral involvement while the remaining patients had bilateral involvement.

11. The rest of the anatomical variants that we encountered included prominent ethmoid bulla (10 patients out of 229; 4.4%), paradoxical middle turbinate (9 patients out of 229; 3.9%), pneumatisation of the vomeral bone (3 patients out of 229; 1.3%), hypertrophy of inferior turbinate (3 patients out of 229; 1.3%), hypoplastic frontal sinus (1 patient; 0.4%) and sinus turbinate (1 patient; 0.4%).

12. No statistically significant relationship could be demonstrated between presence the concha bullosa and predisposition to nasal septal deviation.

13. When deviated nasal septum and concha bullosa are co-existing, there is a high probability (0.97) for the septal deviation to be opposite to the side of the unilateral concha bullosa or in case of bilateral concha bullosa, the septal deviation will be opposite to the side of the dominant concha bullosa.

14. Incidental paranasal sinus abnormality in the form of mucosal thickening or sinus secretions or polyps was detected in 119 out of 229 patients (51.9%). All these patients were asymptomatic for sinus disease.

15. Among the patients with incidental paranasal sinus abnormality, mucosal thickening was most common and was seen in 92 out of 229 patients (40.1%) while secretions were seen in 73 out of 229 patients (31.9%). Mucosal polyps were noted in 7 out of 229 patients (3.0%).

16. Mucosal polyps were noted most commonly in the maxillary sinuses (71.4%).

17. Incidental paranasal abnormalities were most commonly noted in the ethmoid sinuses (36.7%) followed by the maxillary sinuses, sphenoid sinuses and then frontal sinuses in descending order of involvement. The pattern of involvement showed equal incidence of involvement for a single sinus group or simultaneous involvement of two sinus groups (21.8% each).

18. Maxillary and ethmoid sinuses together accounted for 72.2% of the sinuses with incidental findings in our study.

19. No significant statistical association could be demonstrated between presence of anatomical variants and predisposition to incidental paranasal sinus findings (p value 0.3185).

20. Although no statistical association could be demonstrated between presence of deviated nasal septum and predisposition to incidental paranasal sinus findings, we found that in those patients who had deviated nasal septum along with incidental sinus findings, there was a high probability for the affected sinus group to be ipsilateral to the side of septal deviation.

21. Statistically, no significant difference could be demonstrated between the incidences of paranasal sinus abnormality in asymptomatic population on CT as we got according to our study as against the results in similar studies done in other parts of the world.

22. In conclusion, incidental paranasal sinus abnormalities in the form of secretion or mucosal thickening are present in a significant percentage of asymptomatic population and so the mere presence of these findings on CT should not be taken as confirmation of sinusitis in the absence of typical clinical features.

Anatomical variants in the paranasal sinus region are also present in a significant percentage of population, however, there is no evidence of suggest that the mere presence of these variants predispose to incidental sinus findings.

The results we obtained for incidental paranasal sinus findings on CT in asymptomatic population were statistically similar to the results in comparable studies which had been conducted in other countries.

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