Is Non-Contrast Enhanced CT of Paranasal Sinus Adequate for the Diagnosis of Complicated Sinusitis?

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ABSTRACT

Objective: To evaluate the accuracy of NECT compared with CECT of PNS for the detection of complicated sinusitis.
Methods: A retrospective review of 96 patients (mean age, 51.78; range 20-84 years), including 44 men and 52 women, with clinically suspicious complicated sinusitis who underwent both NECT and CECT of PNS. Analysis and comparison between CT PNS on NECT and CECT for detection of complicated sinusitis were performed.
Results: Complicated sinusitis was detected in 7 out of 96 patients. Orbital complications alone in 5 patients and 2 patients with both orbital and intracranial complications were found. Detection of orbital complication on NECT was 5 out of 7 patients, giving a sensitivity of 71.4% and specificity of 100%. Detection of orbital complication on CECT was 6 out of 7 patients, giving a sensitivity of 85.7% and specificity of 100%. In this presented study NECT could not demonstrate intracranial complication such as cavernous sinus invasion and brain parenchymal lesion.
Conclusion: NECT of PNS shows high accuracy for the diagnosis of orbital complication, but low sensitivity for the detection of intracranial complication.

Abbreviations: Contrast enhanced computed tomography (CECT) and non-contrast enhanced computed tomography (NECT), paranasal sinus (PNS), Hounsfield unit (HU)

Keywords: CT paranasal sinus; complicated sinusitis (Siriraj Med J 2018;70: 53-59)

INTRODUCTION

Complicated sinusitis showed increased prevalence in Thailand and this condition generally occurred after developing acute sinusitis from 3.7 to 20%.[1] This condition tends to be found in immunosuppressive patients such as during periods of chemotherapy, bone marrow transplantation, kidney transplantation or immunodeficient patients, because these patients develop severe leukopenia and are prone to be infected by fungal or severe bacterial infections.[2] Complications of sinusitis are classified into three types: osseous, orbital, and intracranial complications in which invasive fungal sinusitis frequently causes severe orbital and intracranial complications.[3] Computer tomography of paranasal sinus should be performed in patients who are suspected to have complicated sinusitis for pretreatment diagnosis and preparation before endoscopic sinus surgery.[4] However patients who develop complicated sinusitis such as patients with underlying chronic kidney disease or diabetes mellitus or both usually have conditions that are risk for contrast-induced nephropathy (CIN).[5] CT findings of invasive fungal sinusitis in immunocompromised patients from prior study of DelGaudio JM et.al,[6] found severe soft tissue edema of nasal mucosa, bone erosion, orbital invasion,

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facial soft tissue swelling and thickening of periantral fat in which infiltration of periantral fat may be the earliest sign of invasive fungal disease.[7] All of these findings of fungal sinusitis from prior studies can be detected on NECT due to no need for tissue enhancement feature for detecting lesion. This will decrease incidence of contrast-induced nephropathy and decrease radiation exposure from CT examination due to only performing NECT study.

However, there is no prior study that has reported about accuracy of NECT for detection of complicated sinusitis and cut off density value of periantral fat area which suggests this condition. The objective of the present study was to evaluate accuracy of NECT for diagnosis complicated sinusitis by comparison with CECT and definite diagnosis by using endoscopic findings or histopathologic examination.

MATERIALS AND METHODS

This study was approved by Institutional Ethics Committee of Faculty of Medicine Siriraj Hospital, Mahidol University and received projected code (Si 476/2556). The informed consent was waived due to retrospective study design.

In total 96 patients (44 males and 52 females) were enrolled with age over 18 years old and clinically suspected complicated sinusitis who underwent NECT and CECT of Paranasal sinuses (PNS) and images were collected. All imaging studies were available on PAC system of Siriraj Hospital during September 2011 to March 2013. All imaging data was reviewed without clinical information and images interpreted from NECT of PNS and CECT of PNS by separation of groups of images for reducing bias.

All patients were performed CT PNS by using GE LightSpeed VCT 64-slices scanner. CT images were done in thickness range from 1.0 to 1.25 mm. Reformation of images on axial and coronal planes were done and these images were used for interpretation. Post contrast images were also performed after injection of iodinated contrast media with dose about 1.5 cc/ kg and scanned by the same scanner. All CT PNS on NECT and CECT images were available on PACs system of Siriraj hospital.

Demographic data of all patients which included age, sex, patient conditions (immunocompromised or immunocompetent) were collected. The organisms that cause complicated sinusitis, endoscopic findings with detail of complications and final diagnosis of patients were also recorded. The presented study was reviewed by a six-year experienced neuroradiologist with double blind of clinical information and images of patients on CECT during CT evaluation. Images of CT PNS on NECT and CECT were reviewed on axial and coronal reformatted images in soft tissue and bone window. Each NECT scan was evaluated for location of sinus involvement and evidence of extrasinus involvement including infiltration of periantral fat, intraorbital extension, facial soft tissue swelling, and intracranial extension if there was demonstration of vasogenic brain edema. Additional quantitative measurement of HU of periantral fat with calculated difference of HU of periantral fat at the same level for evaluating the cut off value of abnormal fat infiltration. Each CECT scan was also evaluated for extrasinus involvement including orbital area (apex, intraconal, extraconal parts) and intracranial area (cavernous sinus and brain parenchyma).

Definite clinical diagnosis was proved by endoscopic finding, histopathologic and microbiologic reports.

Statistical analysis

All continuous (quantitative) data, including patient's age and different Hounsfield Unit (HU) of bilateral periantral fat were reported as mean ± SD. Sex and causative organisms were collected and reported in number and percentage. Validity of imaging data on NECT and CECT of PNS were calculated by comparison with definite clinical diagnosis (gold standard) and shown in sensitivity, specificity, PPV, NPV and accuracy. Statistical analysis was performed with a statistical software package (PASW statistics 18).

RESULTS

In total 96 patients were enrolled who were met inclusion criteria. The mean age was 51.78 years (range, 20-84 years), SD=13.63. There were 44 males and 52 females. Eighty four patients were immunocompetent hosts. Twelve (12.5%) patients were immunocompromised hosts such as diabetes mellitus, HIV infection, lymphoma, SLE, anaplastic anemia and patients who received chemotherapy due to hematologic malignancy.

Location of sinus involvement showed 31 patients with bilateral pansinusitis, 6 patients with right sided pansinusitis and 6 patients had left sided pansinusitis. Most commonly affected sinuses were maxillary sinus, ethmoid sinus, sphenoid sinus, and frontal sinus, respectively.

Causative organisms of sinusitis were reported in Table 1. There were no differences in frequency of causative organisms between immunocompetent and immunocompromised hosts which included bacteria, fungus and mixed organisms (Table 2).

Clinical records showed sinusitis with complication in 7 out of 96 patients which 5 out of 7 patients had

TABLE 1. Causative organism of sinusitis in immunocompetent and immunocompromised hosts

Organisms	Hosts		Total
	Immunocompetent	Immunocompromised	
Not found	63 (75 %)	4 (33.3%)	67 (69.8%)
Bacteria	10 (11.9%)	2 (16.7%)	12 (12.5%)
Fungus	8 (9.5%)	3 (25%)	11 (11.5%)
Bacteria & fungus	3 (3.6%)	3 (25%)	6 (6.3%)
Total	84	12	96

TABLE 2. Positive causative organism of sinusitis in immunocompetent and immunocompromised hosts

Organisms	Hosts	
	Immunocompetent	Immunocompromised
Bacteria	10 (47.6%)	2 (25%)
Fungus	8 (38.1%)	3 (37.5%)
Bacteria & fungus	3 (14.3%)	3 (37.5%)
Total	21	8

orbital complication alone, and 2 out of 7 patients had orbital and intracranial complications. Causative agents in complicated sinusitis were fungus (n=3), bacteria (n=2) and not found organism (n=2). Patients with orbital complication were diagnosed by signs and symptoms of blindness (n=2), orbital abscess (n=1), orbital cellulitis (n=1) and cranial nerve palsy (n=3).

NECT of PNS showed evidence of sinusitis in all patients in which 4 patients had bilateral pansinusitis, 2 patients had bilateral maxillary sinusitis and 1 patient had bilateral maxillary with left ethmoidal sinusitis.

NECT of PNS could detect orbital complication in 5 out of 7 patients (sensitivity 71.4%, specificity 100%, PPV 100%, NPV 97.8% and accuracy 97.9%). (Table 3) CT findings showed infiltration of periantral fat and orbital invasion in all five patients (Fig 1).

CECT of PNS could detect orbital complication in 6 out of 7 patients (sensitivity 85.7%, specificity 100%, PPV 100%, NPV 98.9% and accuracy 98.9%) (Table 4) by using abnormal soft-tissue enhancement at orbital areas such as orbital apex, extraconal or intraconal parts. The clinical record revealed two patients had intracranial complication, one patient had cavernous sinus thrombosis (Fig 2) and another one patient had cavernous sinus thrombophlebitis with pituitary abscess (Fig 3). Both patients had bilateral pansinusitis. NECT

TABLE 3. The accuracy of non-enhanced computed tomography (NECT) of PNS for detecting orbital complication

Modality	CT Finding	Orbital complication (+)	Orbital complication (-)	Total
NECT	Positive	5	0	5
	Negative	2	89	91
Total		7	89	96

TABLE 4. The accuracy of contrast-enhanced computed tomography (CECT) of PNS for detecting orbital complication

Modality	CT Finding	Orbital complication (+)	Orbital complication (-)	Total
CECT	Positive	6	0	6
	Negative	1	89	90
Total	7	89	96	

TABLE 5. Different Hounsfield unit of bilateral periantral fat

Periantral fat	Mean	Std. deviation	Median	Total
Negative complication group	7.67	4.77	7.00	73
Positive complication group	20.26	9.58	19.00	23

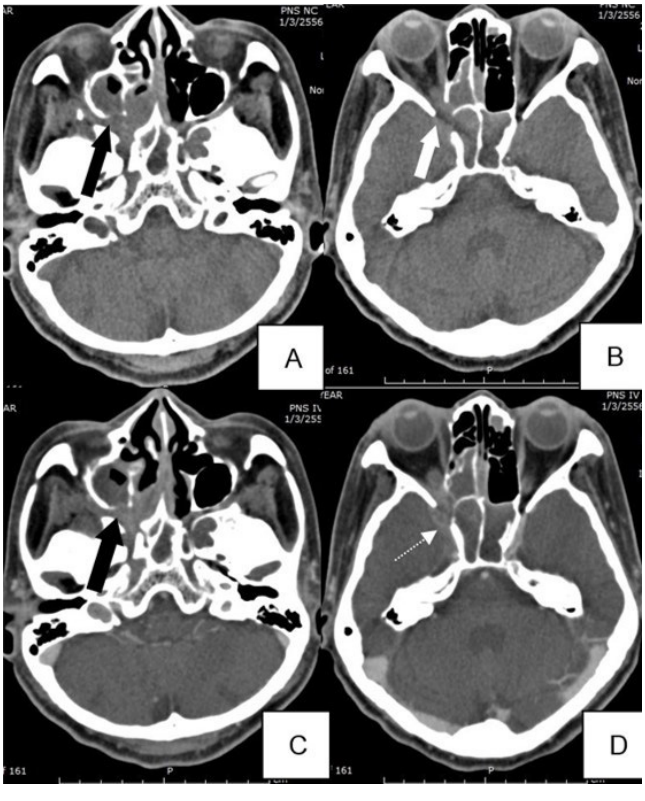

Fig 1. A 63-year-old female underlying poor controlled DM type 2 presented with right sided pansinusitis and right orbital apex involvement from invasive aspergillus infection.
NECT of PNS on image (A)&(B) show fluid filled in right posterior ethmoid sinus and bilateral sphenoid sinuses with demonstrates (A) abnormal soft tissue density lesion inside right pterygomaxillary fissure /pterygopalatine fossa and cause widening of this fissure **(black arrow)**
(B) abnormal soft tissue density lesion also found at right orbital apex and cause widening of orbital apex or superior orbital fissure **(white arrow)**
CECT of PNS on image (C)&(D) show abnormal enhancing soft tissue at the same areas as found on NECT and abnormal bulging of anterior part of right cavernous sinus, which suggestive right cavernous sinus thrombophlebitis **(dash white arrow)**.

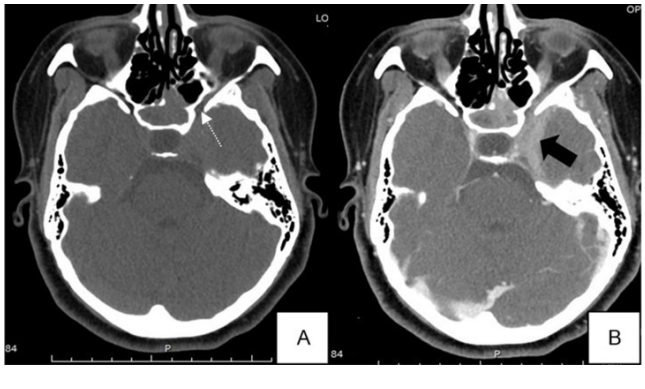

Fig 2. A 31-year-old female presented with left posterior ethmoid and bilateral sphenoid sinusitis and found causative organism from invasive fungal infection. This patient was diagnosed with complicated sinusitis and develop cavernous sinus thrombophlebitis with left orbital apex involvement.
(A) NECT image cannot be demonstrated intracranial complication at left cavernous sinus, but only seen abnormality of abnormal fat infiltration at left orbital apex **(dash white arrow)**.
(B) CECT image shows benefit of contrast study for evaluation intracranial complication due to well demonstrate abnormal enhancement at left cavernous sinus from thrombophlebitis **(black arrow)**.

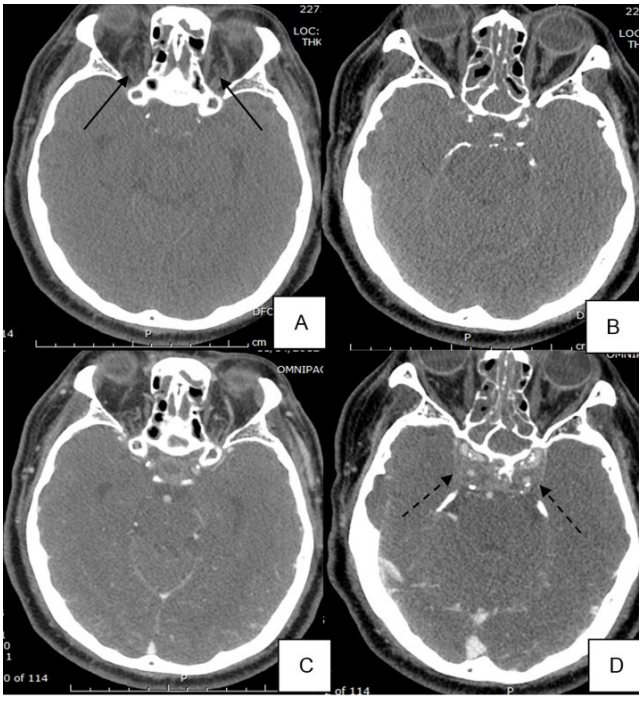

Fig 3. A 63-year-old male presented with bilateral pansinusitis and causative organism from bacterial infection with shown bilateral cavernous thrombosis and orbital involvement from demonstrated retrobulbar fat infiltration.
(A)&(B) NECT image can be detected only orbital complication by demonstrate retrobulbar fat infiltration **(black arrow)**
(C)&(D) CECT image can be demonstrated intracranial complication by detecting abnormal filling defect inside bilateral cavernous sinuses from cavernous sinus thrombosis **(dash black arrow)**

of PNS could not detect two cases with intracranial complication such as cavernous sinus thrombophlebitis, but CECT of PNS could detect in both cases. One case demonstrated abnormal soft tissue enhancement and increased thickening at cavernous sinus which continued from adjacent orbital apex area (Fig 2) and another case showed filling defect inside cavernous sinus with eye congestion from cavernous sinus thrombosis (Fig 3).

The present study also tried to find cut off point value of quantitative measurement of HU of periantral fat infiltration for increasing sensitivity and specificity for detecting early stage of complicated sinusitis from extension of severe infection beyond bony wall of paranasal sinuses which was shown as periantral fat infiltration on CT image, which may be more accurate than visual assessment.

The difference of Hounsfield Unit of bilateral periantral fat in almost all patients with complicated sinusitis should be more than 10 HU (Figs 4 & 5). The significant cut off value of different Hounsfield unit of bilateral periantral fat for which a radiologist can detect abnormality was more than 20.26 HU. (Table 4). Correlation between periantral fat infiltration by using difference of HU of periantral fat area and image findings of sinusitis on NECT may increase confidence for diagnosis of complicated sinusitis.

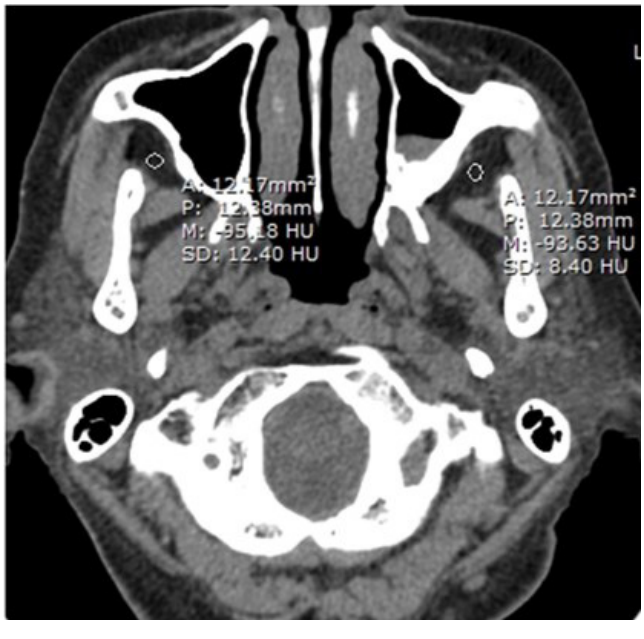

Fig 4. A 53-year-old female patient with chronic bilateral maxillary sinusitis due to detect bilateral maxillary antrums sclerosis and suspected acute sinusitis on top at left side which shows fluid filled inside. NECT of PNS shows no significant different of HU between each sides of periantral fat (different value about 1.55 HU)

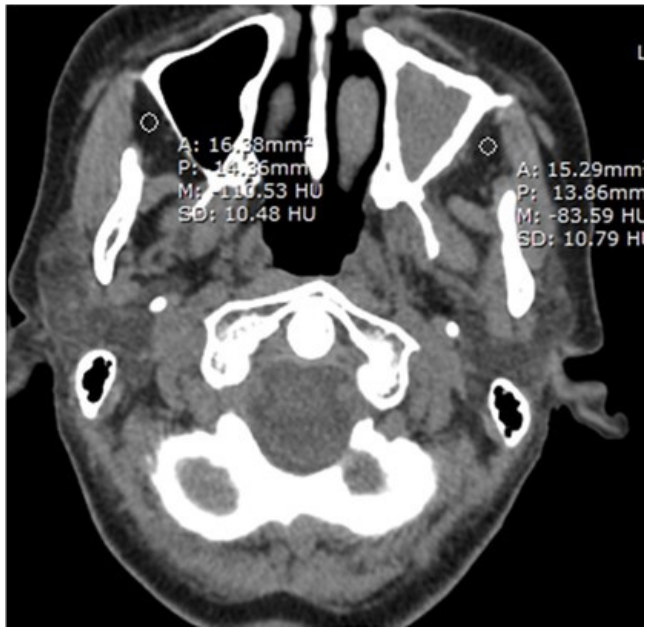

Fig 5. A 59-year-old female with invasive fungal sinusitis at left maxillary sinus. The left maxillary sinus shows evidence of acute on top chronic sinusitis due to detect fluid filled inside with sclerotic change of bony wall. NECT of PNS shows significant different HU between bilateral periantral fat values about 26.94 HU.

DISCUSSION

Severe infection of paranasal sinus will be followed by serious complication especially in patients with immunocompromised or immunocompetent hosts. The causative agents in this condition usually occur from severe bacterial infection such as pseudomonas aeruginosa or Klebsilla or fungal infection such as mucormycosis or aspergillosis.[2] Early diagnosis and appropriated treatment from surgery and medication in case of severe infected sinusitis show more important to safe life and decrease morbidity and mortality of patients. Complicated sinusitis is defined by extension of infection beyond PNS area to adjacent structures such as orbit, adjacent soft tissue or invade into intracranial area at the time of diagnosis.[8] Combination between functional endoscopic sinus surgery (FESS) and CT scan of PNS have benefit and useful for evaluation before treatment due to well demonstrate anatomical and extension of disease such as mass or severe infection.[9] However CECT may be limited in these population due to poor renal function and risk for contrast-induced nephropathy (CIN) that may lead to increased morbidity and mortality rates.[10] Prior study of Pongsakorn et al. showed that limited CT of PNS can be used for surgical roadmap for treatment planning sinus surgery[11], but no previous research study about using NECT of PNS for detecting complicated sinusitis which may be useful for demonstrating lesion before treatment and minimizing the incidence of contrast-induced nephropathy from CECT of PNS.

From the presented study found immunocompromised and immunocompetent patients had bilateral pansinusitis or unilateral pansinusitis as clinical presentation. The first three sinuses that effected from complicated sinusitis were maxillary, ethmoid and sphenoid sinuses, respectively. No significant difference of causative organisms from bacterial and fungus in immunocompromised and immunocompetent patients, but may be from small amount of immunocompromised host when compared with normal host. Main findings of complicated sinusitis in this study were found at periantral area, orbital apex and cavernous sinus without evidence of bony destruction. Del Gaudio et al[6] found that bone erosion and extrasinus extension were highly specific finding of invasive fungal sinusitis. Silverman and Mancuso[7] found that periantral fat infiltration may be earliest sign of invasive fungal sinusitis in the appropriate clinical setting which the presented study also shown this evidence in case of complicated sinusitis by detection abnormal soft tissue infiltration or fat infiltration at periantral area or orbital apex without evidence of bony destruction.

Groppo et al. found sensitivity, specificity, PPV and NPV of CECT for diagnosis of acute invasive fungal sinusitis in immumocompromised patients were 57-69%, 81-83%, 89-93% and 45-67%, respectively.[12] In the presented study showed benefit of NECT of PNS for detection orbital complication due to accuracy about 97.9% which more useful in population who risk to develop contrast-induced nephropathy or severe allergic reaction from contrast.

However, NECT was limited to detect intracranial complication because it depended on enhancing property of soft tissue and vascular structures such as cavernous sinus or brain parenchyma.[13] If clinical suspected intracranial or cavernous sinus involvement, CECT should be performed for better evaluation.

Another additional quantitative datas from this study was the significant different Hounsfield Unit of density value at bilateral periantral fat region for early detecting periantral fat infiltration which Silverman and Mancuso found that this finding may be earliest sign of invasive fungal infection.[7] The cut-off point value of different HU of periantral fat that suggestive complicated sinusitis should be more than 20.26 HU which in non-complicated sinusitis group was measured about 7.67 HU.

Limitations in this study were small number of immunocompromised and immunocompetent patients who had orbital and intracranial complications and positive histopathologic results.

CONCLUSION

NECT of PNS has benefit for diagnosis complicated sinusitis that invade into extrasinus along periantral area and orbital apex in patients who may risk for developing contrast-induced nephropathy such as immunocompromised and immunocompetent host. However CECT of PNS is still necessory for evaluating intracranial complication such as brain parenchyma invasion or cavernous sinus involvement.

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