IJAI (Indonesian Journal of Applied Informatics)
Vol. 7 No. 1 Tahun 2022 pISSN: 2548-3846, eISSN: 2598-5981

Precautions for Pneumo-Orbital In Cases of Maxillofacial Trauma: Data Mining for Artificial Inteligence of Air Localization on CT-Scan

Karla Kalua[1], **Muchtar Hanafi[1,2]***, Rachmi Fauziah Rahayu[1]

[1]Radiology Department Faculty of Medicine UNS
[2]Dr. Moewardi Hospital Surakarta

*Corresponding Author
Email: m.hanafi.dr@gmail.com

Article info

Keywords:
Pneumo-orbital, Le Fort, CT-scan

Date of Article
Submited : 16 October 2022
Revised : 2 November 2022
Accepted : 30 November 2022

Abstract

Along with rapid mobility, the incidence of traffic accidents is increasing. Maxillofacial trauma often accompanies traffic accidents. Facial bone fractures need serious concern, considering the face contains several essential organs and an essential aesthetic aspect daily. Pneumo-orbital, in which air is found in the orbital cavity, threatens vision. The development of diagnostic modalities for maxillofacial trauma is developed continuously to determine the accuracy and improve rapid diagnosis. A radiologist is greatly facilitated by the presence of a CT scan that can detect specific abnormalities through artificial intelligence (AI) features. The data of this study are preliminary data showing the incidence of pneumo-orbital that was often missed in maxillofacial trauma cases. The maxillofacial trauma cases (classified as Le Fort fractures) were consecutively collected from January 2022 to July 2022 and determined into Le Fort fractures with pneumo-orbital and without pneumo-orbital. From 19 cases, 13 cases (68%) were accompanied by pneumo-orbital, while 6 cases (32%) were not. Multiple pneumo-orbitals with relatively visible sizes are detected easily on CT scans, but a single and relatively small pneumo-orbital has potentially not to be seen on CT scans. It is concluded that CT scan nowadays is used to see anatomical abnormalities and is equipped with AI-based features, such as the intracranial bleeding volume calculation and calcium score estimation on cardiac CT. It is possible that a CT scan can also detect the presence of air particles. Thus, the sensitivity of pneumo-orbital detection can be increased.

1. INTRODUCTION

The Indonesian National Police recorded 103,645 traffic accidents with moderate to severe injuries, one of which suffered head and facial injuries. Head trauma causes serious disability if accompanied by intracranial hemorrhages, such as epidural hematoma, subdural hematoma, subarachnoid hematoma, and intracerebral hematoma.

Maxillofacial trauma often accompanies traffic accidents. Fractures of the bones around the face are a warning to consider that the face contains several important organs. Some of these are the organs of smell such as the nose and paranasal sinuses, the organs of taste such as the tongue, and the organs of vision which include the eyes, extraocular muscles, and bones around the right and left orbital cavities. In addition, maxillofacial is also an important aesthetic modality in everyday life. Pneumo-orbital, where the air is found in the orbital cavity, both intraconal and extraconal, is a threat to the vision of patients with maxillofacial trauma. The development of diagnostic modalities for cases of maxillofacial trauma is developed continuously so that it has an excellent performance in determining the accuracy and speed of diagnosis.

A radiologist as a determinant of the diagnosis through the results of a CT scan is greatly facilitated by the presence of features that are able to detect certain abnormalities through artificial intelligence. Detailed CT scan readings of a patient with suspected pneumo-orbital due to multiple maxillofacial fractures provide information for further management of the patient. In this study, the authors attempted to describe all cases of maxillofacial fractures due to traffic accidents to provide an overview of how often multiple fractures of the maxillofacial area classified as Le Fort fractures involved the orbital cavity as a pneumo-orbital.

2. METHODS

This research is a descriptive-analytical study by taking all patients with a diagnosis of multiple fractures of the maxillofacial area (Le Fort) in the period of January to July 2022 consecutively at the Emergency Installation of Dr. Moewardi Hospital Surakarta. The diagnosis of a Le Fort fracture was confirmed by a non-contrast CT scan of the head at the Radiology Department. The diagnosis of pneumo-orbital is made using the same modalities. The examination was carried out by a doctor who had 2-3 years of experience reading cases of maxillofacial trauma consisting of 1 doctor with 1.5 years of experience, 1 doctor with 2 years of experience, and 2 doctors with more than 2 years of experience. CT scan readings are carried out in two different periods, namely at the time of the incident and reading files from backing up data. Data were described and analyzed to determine the frequency of pneumo-orbital and non-pneumo-orbital events in Le Fort fractures. Among the pneumo-orbital cases, it was determined by the severity level of Le Fort fracture to be level I, II, and III. Higher level of Le Fort compared to the incidence of pneumo-orbital.

3. RESULTS AND DISCUSSION

There were 19 cases of maxillofacial trauma (Le Fort) due to traffic accidents, of which 18 patients were male and 1 patient was female. The age of the patients varied where as many as 4 people were over 50 years old, 6 people were between 21 and less than 50 years old and 9 patients were less than 20 years old. Based on the analysis of all cases, 13 cases of Le Fort fracture were accompanied by pneumo-orbital. Meanwhile, 6 cases of Le Fort fracture were not accompanied by a pneumo-orbital. Higher severity level of Le Fort fracture resulted in higher incidence of pneumo-orbital.

Le Fort fractures were first described by Rene Le Fort in 1901, are certain fracture patterns in the facial bones that occur due to blunt facial trauma (most often associated with motor vehicle collisions, assaults, or falls) [1,2]. All types of Le Fort fractures involve the pterygoid process of the sphenoid bone and therefore can impair the support system intrinsic to the face. The difference from Le Fort types I, II, and III lies in the involvement of the maxilla, nose, and zygomatic bone [3,4,5]. Despite the low mortality rate, fractures are often associated with severe head and neck injuries [6]. Thus, the ability to quickly recognize and diagnose Le Fort fractures is very important in the management of blunt force trauma to the face. Le Fort I fracture is an anterior maxillary horizontal fracture that occurs above the palate and alveolus and extends through the lateral wall of the nasal bone and pterygoid plate. This fracture resulted in mobility of the tooth bearing on the maxillary and hard palate of the face and was associated with malocclusion and fracture of the teeth [7]. Le Fort II fractures are pyramidal in shape and involve the zygomaticomaxillary, nasofrontal, pterygoid processes of the sphenoid bone, and frontal sinus causing disruption of medial, lateral, transverse, and posterior maxillary support and resulting in an inferomedial orbital rhyme discontinuity. Orbital involvement can cause extraocular muscle injury, orbital hematoma, rupture or impingement of the eyeball, and damage to the optic nerve. Damage to the medial maxillary bone is associated with epistaxis, cerebral spinal fluid (CSF) rhinorrhea, lacrimal duct, and sac injury, medial canthal tendon injury, and sinus drainage obstruction [4]. Le Fort III fractures involve the nasal bone, medial, inferior, and lateral orbital walls, pterygoid process, and zygomatic arch, resulting in complete separation of the middle face from the skull. These fractures affect the medial, lateral, upper transverse, and posterior maxillary supports and can be associated with orbital complications and CSF rhinorrhea [3,4,5,8].

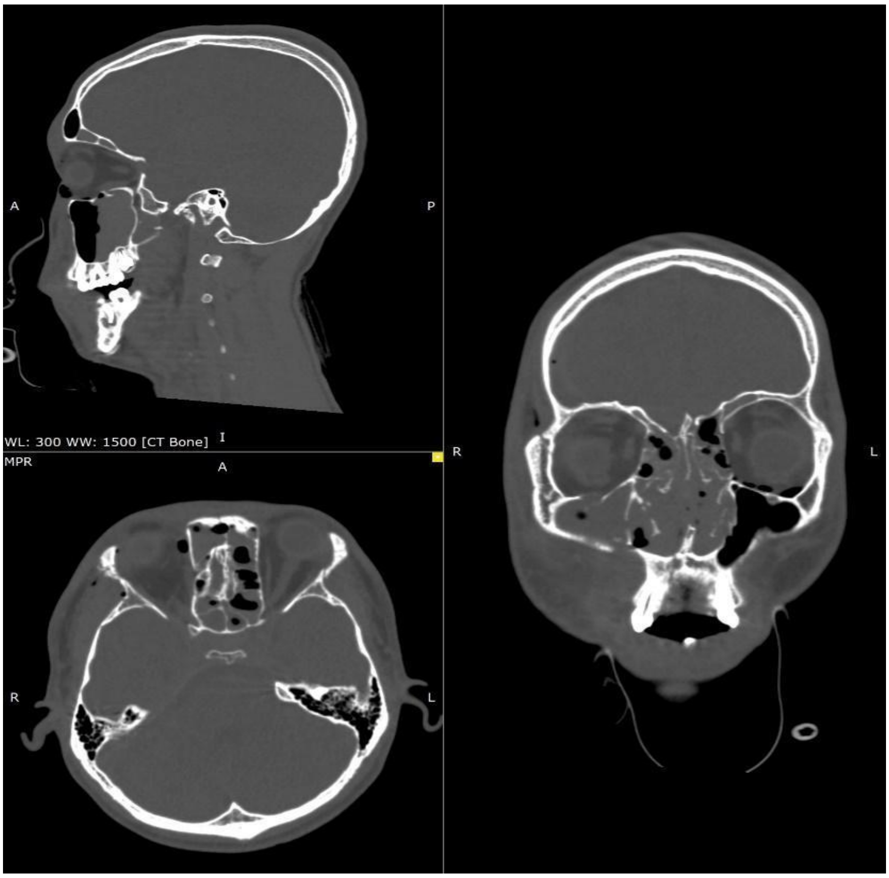

Figure 1. Multiple Pneumo-orbital in left orbital cavity with Le Fort II fracture.

Orbital Emphysema (OE), also known as pneumo-orbital, is generally benign and self-limiting [9]. In trauma, the presence of orbital emphysema is significantly associated with an increased likelihood of orbital fracture [10]. with up to 75% of patients with medial orbital wall fractures also having some degree of orbital emphysema [11]. The clinical presentation of OE varies depending on its severity. Patients often complain of a sensation of pressure or pain and there may be changes in visual acuity or field. Signs of OE include periorbital subcutaneous crepitus, proptosis, subconjunctival emphysema, relative afferent pupillary defect, and decreased vision. Vertical globe dystopia can also be a sign of OE as a cause of orbital compartment syndrome because free air tends to accumulate in the upper part of the orbit [12]. The presence of this free air provides a crescent-shaped radiolucency area in the superior aspect of the orbit on radiographic examination (called the "black eyebrow sign") which is highly suggestive of OE. On CT imaging, air is seen as a hypodense (black/dark) lesion [13,14].

Computer Tomography (CT) scan is a diagnostic tool with a radiographic technique that produces cross-sectional images of the body based on the absorption of x-rays on the body slices displayed on the screen monitors. In a CT scan, to produce an image of the object, the radiation beam generated by the source is passed through an object from various angles. This direct radiation is detected by the detector to be later recorded and collected as input data which is then processed using a computer to produce an image with a method which is known as reconstruction. First clinical image with CT-Scan was first introduced by Godfrey N. Hounsfield and J. Ambrose who worked at the Central Research Lab of EMI, in the UK in 1972. For about 30 years, CT scan technology has been continuously updated and has developed rapidly [15].

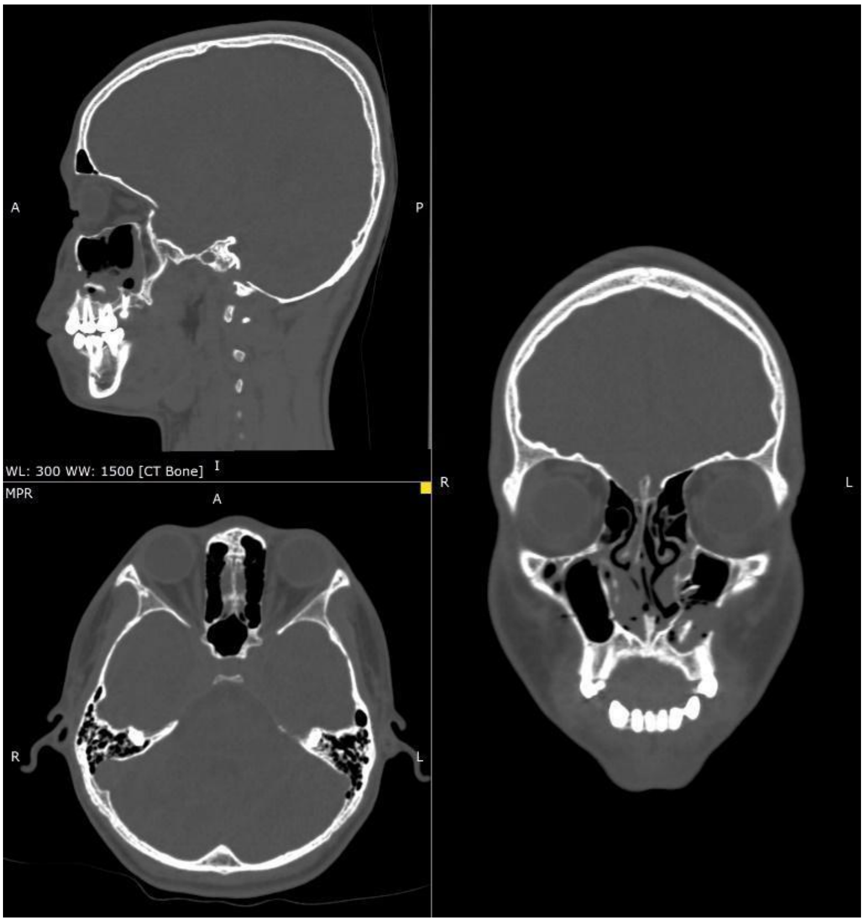

Figure 2. Le Fort I fracture without pneumo-orbital.

CT scan can be categorized into some major developments: helical/spiral data acquisition, multi-slice CT, Dual Source CT, and spectral CT. In 1974, There were 60 CT units installed that were only used for head CT examination, and in 1975, it was then used for the whole body's scanner. These were called the first and the second generation of CT scan, respectively. The third generation CT scan consists of 960 detectors and for the first time a 360° rotating x-ray tube was introduced which results in a shorter scan time than the previous generation. Around 1980, the fourth generation of CT scans was introduced with the technology of fixed rings having 4800 detectors or more. Just like the previous generation, this generation also had an X-ray tube that could rotate 360° around the static object. The fifth generation CT scan used the Electron Beam Technique which did not use an x-ray tube but used an electron gun that produced a beam of electrons with a power of 130 KV. This electron beam was focused by the electromagnetic coil toward the focal spot on the tungsten ring. The process of collision of electrons in tungsten produces x-rays which would then exit through the collimator, hit the object, and the attenuation would hit the solid detector and then the process was the same as others [15].

In 1990, the sixth-generation CT scan with continuous gantry rotation enabled by slip-ring technology and continuous patient transport during data acquisition was introduced. This was called spiral or helical data acquisition. Data acquisition was carried out with a moving table while the x-ray tube rotates and moves in a spiral pattern with respect to the patient. For the first time, volume data became available, and anatomical details and overlapping images could be reconstructed. In this spiral/helical CT, the ability to acquire volume data is also valuable for the use of 3D image processing techniques such as multiplanar reformations, maximum intensity projections, or volume rendering techniques (VRT) [15]. In 1998, different from the previous CT scan that had a two-row scanner, the seventh Generation CT scan with four-row detector systems was clinically available. These multi-slice scanners significantly impacted clinical practice. Since then, the number of detector rows increased quickly from 4 to 8, 16, 32, 64, 128, and 256. When the collimator was opened wider, more approximate data would be obtained and also a thicker piece was obtained thus the use of x-ray energy became more efficient. The eighth generation CT scan was a Dual Source CT (DSCT) scan. DSCT uses two different voltage x-ray tubes connected to two detectors at an angle of about 90^o [15].

The existence of artificial intelligence provides hope for radiologists and the public in relation to diagnosis. The AI integrated in a modality of tools provides input and additional information for a diagnostician, in this case a Radiologist, so that the diagnosis process becomes faster and more accurate. AI is developed through big data which is further analyzed to produce conclusions that can be drawn at the clinical level. Pneumo-orbital events that are often missed will be resolved with AI integrated with radiological modalities such as CT scans.

Currently, CT scans can be used to detect and calculate the amount and volume of bleeding in cases of intracranial hemorrhage. In addition, CT scans can also be used to detect the presence of calcium in blood vessels in cases of arteriosclerosis on thoracic CT scans and cardiac CT scans. With the development of knowledge related to AI and the need for a more complete and accurate diagnosis in a short time, CT scans are also expected to have AI features to detect the presence of air of minus density (shown as Hounsfield Unit, HU), in contrast to fat or liquids. The larger score of the Hounsfield unit showed the greater viscosity of the liquid. The ability of CT scans to detect the presence of air in various cases provides benefits not only for diagnosing pneumo-orbital but also other cases involving air in other organs, such as pneumatoceles in the lungs, pneumocephalus inside the head, or pneumo-ventricular inside the ventricles, the deep part of the brain.

4. CONCLUSIONS

Most cases of Le Fort fracture are accompanied by pneumo-orbital. The absence of pneumo-orbital in a Le Fort fracture is a major task for radiologists and technologists to develop features capable of detecting the presence of air in the orbital cavity. Thus, the diagnosis of patients with maxillofacial trauma becomes more detailed and accurate considering the location of the orbital cavity in pneumo-orbital cases. Bone fractures are located side by side with the orbital cavity and frequently impact the incidence of pneumo-orbital which potentially causes the loss of sight.

With the advancement of CT technology, it is very helpful in establishing the diagnosis of cases, especially in this case of maxillofacial trauma. The faster scanning time, the thinner CT slices help clinicians in detecting the presence of pneumo-orbital in cases of maxillofacial trauma quickly and accurately.

REFERENCES

[1] Noffze MJ, Tubbs RS. René Le Fort 1869-1951. Clin Anat. 2011;24(3):278-81.
[2] Kaul RP, Sagar S, Singhal M, Kumar A, Jaipuria J, Misra M. Burden of maxillofacial trauma at level 1 trauma center. Craniomaxillofac Trauma Reconstr. 2014;7(2):126-30.
[3] Kunz C, Audige L, Cornelius CP, Buitrago-Tellez CH, Frodel J, Rudderman R, et al. The comprehensive AOCMF classification system: Midface fractures - level 2 tutorial. Craniomaxillofac Trauma Reconstr. 2014;7(Suppl 1):S059-67.
[4] Fraioli RE, Branstetter BF, Deleyiannis FW. Facial fractures: Beyond le fort. Otolaryngol Clin North Am. 2008;41(1):51-76, vi.
[5] Patel R, Reid RR, Poon CS. Multidetector computed tomography of maxillofacial fractures: The key to high-impact radiological reporting. Semin Ultrasound CT MR. 2012;33(5):410-17.
[6] Bagheri SC, Holmgren E, Kademani D, Homer L, Bell RB, Potter BE, et al. Comparison of the severity of bilateral le fort injuries in isolated midface trauma. J Oral Maxillofac Surg. 2005;63(8):1123-9.
[7] Brown D, Borschel G. Michigan manual of plastic surgery. Philadelphia: Lippincott Williams and Wilkins; 2004.
[8] Carinci F, Zollino I, Arduino L, Brunelli G, Pagliaro F, Cenzi R. Midfacial fractures: A scoring method and validation on 117 patients. Eur J Trauma Emerg Surg. 2008;34(4):385-90.
[9] Zimmer-Galler I, Bartley G. Orbital emphysema: case reports and review of the literature. Mayo Clin Proc 1994;69:115–21.
[10] Yadav K, Cowan E, Haukoos JS, et al. Derivation of a clinical risk score for traumatic orbital fracture. J Trauma Acute Care Surg 2012;73:1313–8.
[11] Shinohara H, Shirota Y, Fujita K. Implication of differences in the incidence of orbital emphysema in ethmoidal and maxillary sinus fractures. Ann Plast Surg 2004;53:565–9.

[12] Hatton MP, Rubin PA. Management of orbital compartment syndrome. Arch Ophthalmol 2007;125:433–4; author reply 434.
[13] Feyaerts F, Hermans R. The black eyebrow sign in orbital blowout fracture. JBR-BTR 2009;92:251–2.
[14] Sawicki WK, Hunter G. Eyebrow sign in facial trauma. Emerg Med J 2011;28:962
[15] Hsieh J, Flohr T. Computed tomography recent history and future perspectives. J Medical Imaging 2021; 8(5):1-12