Three-Dimensional Reconstruction CT in Diagnosis of Eagle’s Syndrome: a Retrospective Study

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Eagle’s syndrome is defined as symptoms such as neck pain on turning head and pain on swallowing, caused by elongated styloid process or calcified stylohyoid ligament. The purpose of this study is to investigate the effectiveness and reliability of three-dimensional (3D) reconstruction CT to make diagnosis of Eagle’s syndrome. Nineteen patients with clinical suspicion of Eagle’s syndrome underwent CT study in the past 2 years. A multidetector CT (MDCT) scanner was used for data acquisition, and then axial, coronal and 3D image reconstruction was performed. Two radiologists reviewed all the studies, including images with and without 3D reconstruction. The lengths of the styloid processes and the time interval for the readers to report the length of the styloid processes were compared. Nine patients with 11 elongated styloid processes or calcified stylohyoid ligaments (3.87 ± 0.46 cm) were all recognized by the two radiologists with almost perfect interobserver agreement, regardless of 3D images available or not. The interpretation time was significantly less if 3D reconstruction images were available for the readers (p<0.001). There is significant correlation between the styloid process lengths measured on sectional images and on 3D CT. In conclusion, for patients with clinically suspicious Eagle’s syndrome, 3D CT is an effective and reliable imaging tool for the radiologists to make a diagnosis.

Key words: 3D reconstruction; Computed Tomography; Eagle’s syndrome

Eagle’s syndrome was first described by Eagle in 1937 [1]. The etiology is elongated styloid process or calcified stylohyoid ligament, compressing cervical nerve or pharynx, and causing symptoms including neck pain on turning head, pain on swallowing, pharyngeal foreign body sensation, and dysphagia [2]. Diagnosis of Eagle’s syndrome is made by both physical examination and imaging study [3]. On physical examination, palpable styloid process in the tonsillar fossa is considered to be elongated styloid process [2]. The imaging study modalities include plain radiograph such as panoramic radiograph, and lateral head and neck radiograph, and CT scan. Previous studies suggested that the normal length of the styloid process is about 2.5 cm on image study, and length longer than 3 cm is the criterion of elongation [3, 4]. If there is a calcified stylohyoid ligament, it’s added to the length of styloid process [5]. In recent years, several studies indicated that 3D reconstruction CT is useful in the diagnosis of Eagle’s syndrome [5-8], but no previous study statistically analyzed if 3D CT is really an effective and reliable method for radiologists or clinicians to make diagnosis of Eagle’s syndrome.

MATERIALS AND METHODS

From September 2003 to November 2005, 19 patients (7 males and 12 females) were suspected as Eagle’s syndrome by otorhinolaryngology doctors in our hospital. The symptoms were neck pain...
on turning head (n=11) or pain on swallowing (n=8). The patients’ age ranged from 23 to 64 years (mean 44.1, standard deviation 11.1). They all underwent CT study at a MDCT scanner (Lightspeed Plus 4i, GE Healthcare, Milwaukee, WI, USA) for data acquisition. The MDCT scanning protocol was 2.5 mm slice thickness and 1.25 mm gap, with 120 kV and 250 mA, scanned in axial plane, from clavicle to frontal sinus. Forty seconds after starting intravenous injection of 60 mL iohalamate meglumine (Conray 60; Tyco Healthcare, Montreal, Quebec, Canada; 282 mg of iodine per mL) by a power injector at a fixed rate of 1 mL/sec, enhanced CT scan was performed with the same scanning protocol. The non-enhanced images were then processed by a technician. Axial and coronal reconstructions were done in 3 mm thickness, and 3D reconstruction was processed on a workstation (GE Advantage Workstation, GE Healthcare, Milwaukee, WI, USA), using “volume rendering” software. The enhanced images were processed to get axial reconstruction images in 3 mm thickness.

Two experienced radiologists, who were blind to the final diagnosis, reviewed all the studies, both with and without 3D reconstruction images, at a PACS (Picture Archiving and Communication System) workstation (GE Centricity Radiologist Workstation, version 2, GE Healthcare, Milwaukee, WI, USA). A styloid process longer than 3 cm was the criterion of Eagle’s syndrome. The calcified stylohyoid ligament near styloid process was added to the length of styloid process [5]. The correlation between lengths measured on sectional images and on 3D reconstructed images was analyzed with Pearson correlation coefficient. The agreement between the two radiologists was studied with κ statistic values, both with and without the information of 3D images. The κ values were graded as: κ values of 0–0.20 indicated poor agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, good agreement; and 0.81–1.00, almost perfect agreement [9].

The interpretation time was defined as the time interval for a reader to report the length of the styloid processes, and was counted by another doctor with a stopwatch. The interpretation time with and without the information of 3D reconstruction images was then analyzed with independent two-sample t test. In this study, only the reconstructed images from non-enhanced CT were used to study the interpretation time, and enhanced CT images, though important to exclude other disease, were not used to determine the effectiveness of 3D CT. The correlation of patient’s gender and age with the styloid process length was analyzed with two-sample t test and linear regression respectively. Values were reported as mean ± standard deviation. All statistical analyses were performed using Stata version 9.2 statistical software (StataCorp LP, College Station, TX, USA). For all analyses, P values less than 0.05 were considered to indicate statistical significance.

**RESULTS**

Nine (4 males and 5 females) of the 19 patients were finally diagnosed as Eagle’s syndrome, and they were all recognized by two radiologists. Seven patients had 8 elongated styloid processes (Fig. 1) and 2 patients had 3 calcified stylohyoid ligaments near styloid processes (Fig. 2), which length was added to the measurement. The length of the elongated styloid processes was 3.87 ± 0.46 cm, as shown in Table 1. There was significant correlation between the length measured on sectional images and the length measured on 3D CT (Pearson correlation coefficient: 0.99). Regardless of 3D images available or not, the κ values were both 1.00, indicating almost perfect interobserver agreement in making correct diagnosis of Eagle’s syndrome.

The interpretation time was significantly decreased if 3D images were available (Table 2). There was no statistically significant difference

### Table 1. Number and length of elongated and not elongated styloid processes

<table>
<thead>
<tr>
<th></th>
<th>Elongated</th>
<th>Not elongated</th>
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<tbody>
<tr>
<td>Number of styloid process</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Length of styloid process (cm) (mean ± SD)</td>
<td>3.87 ± 0.46</td>
<td>2.34 ± 0.54</td>
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</table>

### Table 2. Interpretation time with and without 3D images

<table>
<thead>
<tr>
<th></th>
<th>With 3D</th>
<th>No 3D</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Interpretation time (second) (mean ± SD)</td>
<td>13.9 ± 2.4</td>
<td>35.0 ± 2.2</td>
<td>&lt;0.001</td>
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### Table 3. Number of male and female patients and length of styloid processes

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Number of patients</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Length of styloid process (cm) (mean ± SD)</td>
<td>3.24 ± 0.73</td>
<td>2.75 ± 0.95</td>
<td>0.22</td>
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</table>
between the styloid process length in women and in men (Table 3). In linear regression, the patient’s age and the styloid process length was not significantly correlated (P = 0.64).

The CT findings of the 9 patients with final diagnosis of Eagle’s syndrome can explain the symptoms, which was corresponding to the abnormal side where of a elongated styloid process or calcified stylohyoid ligament was present. Three of them underwent surgical resection, 2 for elongated styloid process and 1 for calcified stylohyoid ligament. All of the 3 patients got complete symptom relief without recurrence during a follow-up period at least for 6 months.

Among the 10 patients without elongated styloid process or calcified stylohyoid ligament, there was no significant abnormality in 9 patients, but hypopharyngeal tumor was diagnosed in one patient, who had dysphagia as the presenting symptom. The length of the left and right styloid processes of this 51-year-old man were both 2.3 cm, on both sectional images and reconstructed images. He received surgical resection for the tumor and the pathology revealed squamous cell carcinoma.

**DISCUSSION**

Nakamaru and his coworkers reported their experience of 3D reconstruction CT in 4 patients suspected as Eagle’s syndrome, with two of the patients diagnosed as Eagle’s syndrome [6]. They found 3D CT useful in diagnosis of Eagle’s syndrome, because it allowed direct measurement of the length of the styloid process or stylohyoid ligament. Basekim and colleagues [5] reported a series of 138 asymptomatic cases, and they concluded 3D CT was good for evaluation of styloid process, but for symptomatic patients, the relationship between clinical symptoms and imaging findings deserved further studies. Beder et al. [7] and Savranlar et al. [8] used 3D CT to study Eagle’s syndrome in 5 and 3 cases respectively. These studies pointed out the potential benefit of 3D CT in the diagnosis of Eagle’s syndrome. However, there was no previous study statistically analyzing the effectiveness of 3D CT to make diagnosis of Eagle’s syndrome. Our study indicates that if 3D images are available, the time interval to make imaging diagnosis of Eagle’s syndrome would be significantly decreased. Besides, generally it only takes several seconds for an experienced technician to do 3D image reconstruction in our hospital, just like doing axial and coronal reconstructions, making it a feasible method for the diagnosis of Eagle’s syndrome in daily practice.

The styloid process cannot be demonstrated on a single axial or coronal reconstructed image in most cases. To determine the length of styloid process, we need to multiply the axial section thickness (3 mm in our study) and the number of axial images which showed styloid process, and it is time consuming. However, the styloid process is seldom perpendicular to axial images, therefore, the above calculation is not accurate, unless counting the number of coronal images which showed styloid process and using the...
Pythagorean theorem \( (A^2 + B^2 = C^2) \), which is even more time consuming. On the contrary, to measure the length of styloid process on 3D image is very convenient, and it’s just one step on a PACS system. Other studies using 3D CT to evaluate styloid process did not analyze the correlation between axial or coronal images and 3D images. The high correlation between the styloid process length measured on sectional images and on 3D CT disclosed the accuracy of 3D images is as good as that of sectional images.

Previous study suggested that age and gender did not show correlation with the length of styloid process [5], so did our results. A patient with pharyngeal cancer presented as Eagle’s syndrome was reported in the literature [6]. One of our patients with suspicious Eagle’s syndrome by otorhinolaryngology doctor turned out to have hypopharyngeal tumor rather than elongated styloid process on CT study. It is of no doubt that intravenous contrast medium administration is important for adequate imaging interpretation on head and neck CT scans [10], especially when there is a small tumor or an enlarged lymph node. Other studies about evaluation of Eagle’s syndrome by 3D CT did not include contrast enhanced CT study. To avoid misdiagnosis and subsequent medical legal problems, in addition to evaluate the styloid process by 3D reconstruction images from non-enhanced CT, it will be recommended to perform an enhanced CT scan to exclude other diseases such as neoplasm or lymphadenopathy.

CONCLUSION

For clinically suspected cases of Eagle’s syndrome, 3D reconstruction CT provides an effective and reliable imaging tool to make a correct diagnosis.

REFERENCES

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以立體重組電腦斷層影像診斷Eagle氏症候群：回顧性研究

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Eagle氏症候群是指較長的莖突或是鈣化的莖突舌骨韌帶，造成轉頭時頸部疼痛或吞嚥時喉嚨痛等症狀。本研究的目的在探討以立體重組電腦斷層影像診斷Eagle氏症候群是否有效且可靠。在過去兩年中，十九位臨床上懷疑Eagle氏症候群的患者接受了電腦斷層檢查。我們使用多排探頭電腦斷層，並重組出横切面、冠狀切面、以及立體重組影像。兩位放射科醫師分別在有及沒有立體重組影像的情況下，判讀了所有檢查的影像，然後我們比較報告的莖突長度及測量莖突長度所需的時間。九位患者有十一個較長的莖突或是鈣化的莖突舌骨韌帶。不論有沒有立體重組影像可以判讀，兩位放射科醫師對Eagle氏症候群的診斷沒有差異。如果有立體重組影像，判讀所需的時間可以顯著的減少。在切面影像和立體重組影像之間有顯著的相關。當臨床上懷疑Eagle氏症候群時，立體重組電腦斷層是有效且可靠的影像診斷工具。

關鍵詞：電腦斷層攝影；Eagle氏症候群