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Original Contribution

The possibility of application of spiral brain computed tomography to traumatic brain injury☆

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ABSTRACT

Objectives: The spiral computed tomography (CT) with the advantage of low radiation dose, shorter test time required, and its multidimensional reconstruction is accepted as an essential diagnostic method for evaluating the degree of injury in severe trauma patients and establishment of therapeutic plans. However, conventional sequential CT is preferred for the evaluation of traumatic brain injury (TBI) over spiral CT due to image noise and artifact. We aimed to compare the diagnostic power of spiral facial CT for TBI to that of conventional sequential brain CT.

Methods: We evaluated retrospectively the images of 315 traumatized patients who underwent both brain CT and facial CT simultaneously. The hemorrhagic traumatic brain injuries such as epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, and contusional hemorrhage were evaluated in both images. Statistics were performed using Cohen's κ to compare the agreement between 2 imaging modalities and sensitivity, specificity, positive predictive value, and negative predictive value of spiral facial CT to conventional sequential brain CT.

Results: Almost perfect agreement was noted regarding hemorrhagic traumatic brain injuries between spiral facial CT and conventional sequential brain CT (Cohen's κ coefficient, 0.912). To conventional sequential brain CT, sensitivity, specificity, positive predictive value, and negative predictive value of spiral facial CT were 92.2%, 98.1%, 95.9%, and 96.3%, respectively.

Conclusion: In TBI, the diagnostic power of spiral facial CT was equal to that of conventional sequential brain CT. Therefore, expanded spiral facial CT covering whole frontal lobe can be applied to evaluate TBI in the future.

1. Introduction

Management of complex, multiple-trauma patient in emergency setting is always a challenge, requiring numerous analyses and treatments within limited time. The golden time for severe trauma patient usually means the time from its onset to the time of hemostatic procedure or surgical treatment, which is set at 60 minutes in several studies [1-5]. Improved evaluation and management in emergency department (ED) are especially important in nations that have already established basic emergency medical services [6]. However, the prompt surgical management or radiological interventions such as vascular embolization for hemostasis in severe trauma patients are often delayed for various reasons in these nations.

The whole-body computed tomography (CT) is accepted as an essential diagnostic method for evaluating the degree of injury in severe trauma patients and establishment of therapeutic plans [7-9]. Imaging techniques for CT have continuously improved since its first invention in 1979, and currently, 64-channel multidetector CT is more widely used. The conventional sequential CT had several limitations including poor visualization of posterior fossa and bony artifact. On the other hand, the spiral CT had the advantage of shorter test time required and its multidimensional reconstruction providing 3-dimensional image, although there were some limitations such as decreased image clarity. Therefore, it is now used for anatomical evaluation of practically all body parts with the development of the technology [10,11]. Technical advancements of spiral imaging technique have remarkably reduced the time of CT evaluation and

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could make CT into a criterion standard of evaluation even in the hemodynamically unstable patients regarded as the contraindication in the past. Recently, several emergency centers are now integrating the previously separated brain, facial, cervical, thoracic, and abdominal CT protocols together in efforts to minimize test time. However, still, most hospitals are using the conventional sequential imaging technique for brain CT, as there is notion that imaging technique for facial CT is unable to obtain clear image as the conventional technique due to image noise and artifacts generated from the skull. Recently, radiation exposure from CT is of particular concern. Although the issue is debatable, concern that even a single typical CT examination may confer a small but real risk of carcinogenesis is increasing [12,13]. The spiral CT has the advantage of low radiation dose in comparison with conventional CT. Average tube output of axial brain and face/orbit/sinus protocol in GE Lightspeed VCT (General Electric Medical Systems, Milwaukee, WI, USA) used in this study was 51.1 mGy and 8.3 mGy in CT dose index, respectively.

The objective of this study was to evaluate the diagnostic utility of facial CT in patients with head trauma by comparing the images of conventional sequential brain CT and spiral facial CT, respectively. Therefore, we hypothesized that, in patients with traumatic brain injury (TBI), the diagnostic power of spiral facial CT would be similar to that of conventional sequential brain CT.

2. Methods

During the period from January 1, 2013, to June 30, 2013, patients who visited the ED for head or facial trauma and were evaluated with brain CT and facial CT simultaneously were retrospectively reviewed of their medical charts. The protocol for head and/or facial trauma in our institution consists of conventional sequential brain CT followed by a spiral facial CT. The brain CT image is generated through conventional sequential imaging technique, taking images 5 mm apart starting from the basal section/plane of the brain following the long axis, tilted 20° to 40°. The spiral imaging technique takes images 2.5 mm apart, following the long axis tilted at 90°, spirally.

All CT images from patients included in this study were generated by 64-channel multidetector CT (Lightspeed VCT), and the time difference of 2 tests was within 1 hour. Each study was usually completed within 5 minutes. The actual scan time of acquiring each image usually took less than 30 seconds. One team consisting of radiologist and emergency physician evaluated only conventional sequential brain CT without clinical information. The other team consisting of emergency radiologist and emergency physician evaluated only spiral facial CT without clinical information. The 2 test results were compared for agreement, and the cause of discrepancy was analyzed and summarized if discrepant. The test was classified as positive if epidural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, or contusional hemorrhage was visible from the images or was classified as negative.

To evaluate the difference of resulting diagnosis of TBI between 2 techniques, the Cohen's κ index was used. The Cohen's κ index is a numerical representation of the agreement between 2 different tests, classified into 5 intervals: less than 0, 0.1 to 0.4, 0.41 to 0.6, 0.61 to 0.8, and greater than 0.81, interpreting below 0 as "no agreement" and above 0.81 as "almost perfect agreement." Based on brain CT interpretation, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

All statistical analyses were performed with the SPSS statistical package for Windows, version 19.0 (SPSS, Chicago, IL). The study was approved by the institutional review board of our hospital.

3. Results

A total of 315 patients were included in the study. Their mean age was 45.1 ± 20.0 years, consisting of 8.9% (n = 28) younger than 16 years, 73.3% (n = 231) from 16 to younger than 65 years, and 17.8% (n = 56) older than 65 years. The proportion male patients was 71.7% (n = 226), and female patients, 28.3% (n = 89).

Hemorrhage was identified in 32.4% (n = 102) of patients by conventional sequential brain CT. The concurrent positive result rate of facial CT was 92.2% (n = 94), whereas 7.8% (n = 8) were negative by facial CT. Negative result by brain CT was 67.6% (n = 213), whereas facial CT showed positive result in 1.9% (n = 4) from these brain CT negative patients (Table 1).

Cohen's κ index between 2 techniques was 0.912, showing "almost perfect agreement." The sensitivity, specificity, PPV, and NPV of facial CT based on result of brain CT were 92.2%, 98.1%, 95.9%, and 96.3%, respectively (Table 2).

Among the 8 cases of brain CT and facial CT negative patients, 7 patients had frontal lobe hemorrhage, which is beyond the area covered by facial CT. Such 7 cases included 2 intracranial hemorrhages, 3 parafalcine subdural hematomas, and 2 subarachnoid hemorrhages. One case that had hemorrhage within the covered area of facial CT but interpreted as negative has small amount of subarachnoid hemorrhage.

Of the 4 cases of brain CT–negative and facial CT–positive cases, 2 were a small amount subdural hematoma of the frontal lobe in proximity to the basal area. One case was later identified as false positive by follow-up brain and facial CT, whereas the other case with ambiguous facial CT image had no further evaluation.

4. Discussion

According to the study result, a high Cohen's κ index was found between conventional sequential and spiral image techniques. No statistical difference was found between 2 techniques in diagnosis of TBI. In addition, most hemorrhagic lesions seen on conventional sequential brain CT were mostly identifiable with facial CT obtained with spiral imaging technique, whereas small amount of basal hemorrhages, which were unidentified or ambiguous on brain CT, could be readily identified by facial CT. Although not included in this study, small pneumocephalus was only identified with spiral facial CT but not with conventional sequential brain CT.

There were several previous studies that compared conventional and spiral imaging techniques. They concluded that the difference was minimal, but these studies were comparison of identifying normal structural discriminative powers and not hemorrhagic brain lesions. Two studies qualitatively compare first-generation spiral CT with conventional CT about their ability to identify physiologic brain structure [14,15]. Bahner et al [14] describe superiority of conventional brain CT in discrimination of nontraumatic brain lesions from normal brain tissue and qualitative aspects such as image noise and artifacts, therefore recommending spiral CT only when 3-dimensional reconstruction is necessary. Kuntz et al [15] state that 2 imaging techniques show no statistical difference in their ability to differentiate artificial contrast, gray mater, and white mater. These comparisons are limited by their comparison of ability to differentiate physiologic brain structure and qualitative comparison but not of differentiating pathologic lesions. A recent study by Reichelt et al [16] has found that conventional brain CT and spiral CT image by multidetector CT for multiple-trauma patients are not different in mechanical image quality and their ability to differentiate brain structures, announcing the possibility of clinically applying spiral CT imaging technique.

Table 1
Cross-table between sequential brain CT and spiral facial CT

		Sequential brain CT	
		+	−
Spiral facial CT	+	94	4
	−	8	209