Values of Sinogram Affirmed Iterative Reconstruction Algorithm-Based Low-Dose Computed Tomography Imaging in Clinical Diagnosis of Cerebral Hemorrhage

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1. Introduction

Cerebral hemorrhage is a cerebrovascular disease that refers to the bleeding caused by the rupture of the blood vessels of the nontraumatic brain parenchymal tissue, which is a more common clinical disease [1]. The main cause of cerebral hemorrhage is the pathology of cerebrovascular tissue, which is closely related to factors such as hyperlipidemia, diabetes, high blood pressure, aging of blood vessels, and smoking [2]. Patients suffering from intracerebral hemorrhage often take emotional excitement or excessive exertion as the inducement, and there is a very high mortality rate in the early stage of the disease, while most of those who survive will have sequelae to varying degrees [3,4]. This disease accounts for 20%-30% of all stroke patients and is characterized by rapid onset, with the mortality rate of patients in the acute stage reaching 30%-40% [5,6]. Therefore, accurate and timely clinical diagnosis is essential. At the present stage, the main means of examination for suspected patients with intracerebral hemorrhage is a craniocerebral computed tomography (CT) scan. However, as the condition of intracerebral hemorrhage is prone to recurrence and changes,
multiple scans of intracerebral hemorrhage patients are needed to determine the condition of the disease, so that the clinical treatment plan can be changed [7,8]. The images scanned by CT with the features of high resolution, clear pixels, and no artifacts can provide clear diagnostic evidence for the clinical treatment of patients. However, studies have found that plain CT examination is a means of examination with the highest radiation dose, and multiple CT scans will lead to an increase in radiation dose, which will have adverse effects on the health of patients [9,10]. Therefore, the dose of scanning ray should be reduced as far as possible while not affecting the diagnosis of a cerebral hemorrhage.

The sinogram affirmed iterative reconstruction (SAFIRE) algorithm is a new iterative reconstruction algorithm developed by Siemens, which is an iterative reconstruction algorithm based on the original data [11]. It can extremely reduce the noises of CT images and has a significant effect on the removal of spiral CT artifacts. This algorithm can be applied in CT image reconstruction to effectively improve the image quality, which can further reduce the radiation dose of CT scans [12]. Moreover, related studies have proved that the improvement of SAFIRE technology can decrease the CT scan dose without increasing the noise of the CT image, and the impact on the image quality is relatively small [13].

Therefore, the SAFIRE algorithm was combined with low-dose CT scanning technology in this study to greatly reduce the amount of harmful radiation during the CT scan of patients with cerebral hemorrhage and to normally show the scanned CT images of the patients’ condition. In addition, the method was adopted in the examination and diagnosis of the disease of patients with cerebral hemorrhage, to evaluate the diagnostic value of the method, thereby providing a more advantageous and less harmful examination method for the diagnosis and treatment of the disease of patients with cerebral hemorrhage.

2. Research Methods

2.1. Research Objects. In this study, 132 patients with cerebral hemorrhage were selected randomly as the research objects, who were admitted to the hospital from May 2018 to March 2021. Among them, 79 were male patients and 53 were female patients; they were 35–75 years old, with an average age of 56.67 ± 3.31 years old. Then, all patients were divided into the experimental group and the control group based on their wishes. 59 patients who were willing to be examined by the low-dose CT imaging technology based on the SAFIRE algorithm were assigned to the experimental group. Other patients who did not want to use the combination method were examined using conventional low-dose CT scans and assigned to a control group of 73 patients. In addition, this study was approved by the Medical Ethics Committee.

2.2. CT Examination and SAFIRE Technology Reconstruction

2.2.1. CT Examination. All patients were examined by low-dose CT scanning, and the scanning equipment used was Siemens Dual-Source Flash CT (SOMATOM definition Flash, Siemens Healthcare, Forchheim, Germany).

Scanning position of the patients: they took the supine position, the head was placed on the head frame, the mandible was retracted, the sagittal plane of the skull and body coincided with the midline of the mesa, the two external ear holes were equidistant from the mesa, the hands were placed on both sides of the body, and the scanning baseline was the auditory canthus line. Besides, the specific scanning method is shown in Figure 1.

2.2.2. SAFIRE Technology Reconstruction. The CT images of the patients in the experimental group were reconstructed using the SAFIRE algorithm. The brain CT reconstruction parameters of the SAFIRE iterative algorithm were SAFIRE 3, and the convolution kernel J30s medium smooth. The conventional CT images of the control group were used as the scanning results of the examination. SAFIRE algorithm introduced two sets of cyclic iteration based on the initial iterative reconstruction technology.

First, the iterative process in the image domain: the original data are used to reconstruct the image, and the image prior knowledge is used to perform repeated iterative correction in the image space. This process is image denoising, which does not reduce the contrast of the image. It is assumed that the initial image is X; then, ΔX updates a correction value each time.

\[ ΔX = \begin{cases} ΔX_k, & (k \leq \eta, \leq 0), \\ ΔX_1, & \end{cases} \]

where \( k \) represents the iteration sequence number and \( q_i \) represents the real number.

Second, the result of image domain iteration is transformed into the original data domain. A CT simulator is established in the computer, the result of image domain iteration is used as the inspection object, and the simulated scan result is obtained through calculation. The difference between the simulated scan results and the actual original data is used as the noise template, which is converted to the imaging domain by FBP and superimposed on the last reconstructed image, and the iterative reconstruction of the image domain is carried out again. This cycle is repeated 1.5 times to obtain the final diagnostic image.

2.3. Evaluation Indicators

(1) CT images of patients from the two groups were scored subjectively according to the scoring criteria [14], as shown in Table 1. The main method was to average the scores of two clinically experienced chief physicians (more than 20 years of working experience) based on the gray-white matter boundary, sulcus, cistern display, image sharpness, and diagnostic acceptability. Moreover, there were 5 grades, including unqualified (1–2 points), qualified (3 points), good (4 points), and excellent (5 points); the grading was carried out based on the above. Furthermore, the excellent and good rate = (the number of the excellent + the number of the good)/total cases × 100%.
(2) CT images of patients from the two groups were objectively scored, including the average CT values of gray matter, white matter, cerebral hemorrhage, standard deviation (SD) of the image noise, signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR). Average CT values were measured at the body level of the lateral ventricle, and the region of interest (ROI) was set at 5 mm². Cerebral sulci and blood vessels were avoided as far as possible during measurement. Image noise refers to the standard deviation (SD) of average CT value. When, the expression equation of SNR and CNR is as follows:

\[
\text{SNR} = \frac{CT_p}{SD},
\]

\[
\text{CNR} = \frac{CT_{p_1} - CT_{p_n}}{SD},
\]

where \(CT_p\) is the average CT value, \(CT_{p_1}\) is the average CT value of cerebral hemorrhage focus, \(CT_{p_n}\) is the average CT value of brain parenchyma, and \(SD\) is the standard deviation of background SD [15].

2.4. Statistical Methods. The SPSS22.0 statistical software system was used for data entry, sorting, and statistical analysis. The count data were compared by \(X^2\) test, and the measurement data were compared by the \(t\)-test. Analysis of variance (ANOVA) was used for comparison of multiple sample average values, the least significant difference (LSD) method was used for homogeneity of variances, and the Dunnett’s T3 method was used for heterogeneity of variances. Besides, \(P < 0.05\) indicated that the difference was statistically substantial. The Kappa test was conducted for the consistency of subjective scores of the two physicians. When Kappa >0.75, the consistency was strong; when 0.4 ≤ Kappa <0.75, the consistency was moderate; and when Kappa <0.4, the consistency between the two was poor.

3. Results

3.1. Comparison of General Treatment. The statistics of age, sex, bleeding location, causes of intracerebral hemorrhage, and other general data of patients in the experimental group and the control group was performed (Table 2). In terms of gender distribution, the proportion of male patients was 60.27% (44/73) in the control group and 59.32% (35/59) in the experimental group. The proportion of female patients was 39.73% (29/73) in the control group and 40.68% (24/59) in the experimental group. In terms of average age, the control group was (54.67 ± 2.89) years old. The experimental group was (56.01 ± 3.22) years old. As for the bleeding site, putamen was 46.58% (34/73) in the control group and 47.45% (28/59) in the experimental group. Cerebral cortex was 24.66% (18/73) in the control group and 27.12% (16/59) in the experimental group. Cerebellum was 15.07% (11/73) in the control group and 11.86% (7/59) in the experimental group. Thalamus was 9.59% (7/73) in the control group and 8.47% (5/59) in the experimental group. Simple ventricle was 4.11% (3/73) in the control group and 5.08% (3/59) in the experimental group. As for the causes of bleeding, traumatic bleeding was 43.84% (32/73) in the control group and 45.76% (27/59) in the experimental group. Hypertensive hemorrhage was 39.73% (29/73) in the control group and 38.98% (23/59) in the experimental group. Cerebral vascular malformation caused hemorrhage: 16.44% (12/73) in the control group and 15.25% (9/59) in the experimental group. The comparison of the above statistical results is not statistically significant (\(P > 0.05\)), suggesting that the research results of the above two groups are comparable.

3.2. CT Imaging Manifestations of Different Parts of the Cerebral Hemorrhage in Patients from the Control Group. Figure 2 shows the CT image performance of different hemorrhage sites of different patients with cerebral hemorrhage in the control group during this study. Figure 2(a) shows a CT image of a patient with hemorrhage in the cerebellum; Figure 2(b) shows a CT image of a patient with hemorrhage in the putamen; Figure 2(c) shows a CT image of a patient with hemorrhage in the hypothalamus; Figure 2(d) shows a CT image of a patient with hemorrhage in the ventricle. In the CT images of the above different
Table 1: Subjective scores and grading standards of the CT images.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score (points)</th>
<th>Display standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disqualification</td>
<td>1</td>
<td>The anatomical structure and lesion of the image were blurred and there were many artifacts, so it could not be completely diagnosed.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>The anatomical structure and lesion of the image were not displayed, so it was impossible to find the details in the image.</td>
</tr>
<tr>
<td>Qualification</td>
<td>3</td>
<td>Most of the image anatomical structure and lesions could be diagnosed, but a few images were not clear.</td>
</tr>
<tr>
<td>Good</td>
<td>4</td>
<td>The structure, detail, and focus of the image were clear enough to make a diagnosis, but not very satisfactory.</td>
</tr>
<tr>
<td>Excellent</td>
<td>5</td>
<td>There was no artifact, and the image details and lesion sites were displayed, which could provide a clear diagnostic basis.</td>
</tr>
</tbody>
</table>

Table 2: General clinical data statistics of the two groups of patients.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Experimental group (n = 59)</th>
<th>Control group (n = 73)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>35 (59.32%)</td>
<td>44 (60.27%)</td>
</tr>
<tr>
<td>Male</td>
<td>24 (40.68%)</td>
<td>29 (39.73%)</td>
</tr>
<tr>
<td>Average age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putamen</td>
<td>54.67 ± 2.89</td>
<td>56.01 ± 3.22</td>
</tr>
<tr>
<td>Cerebral hemispheric cortex</td>
<td>28 (47.45%)</td>
<td>34 (46.58%)</td>
</tr>
<tr>
<td>Bleeding site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>7 (11.86%)</td>
<td>11 (15.07%)</td>
</tr>
<tr>
<td>Thalamus</td>
<td>5 (8.47%)</td>
<td>7 (9.59%)</td>
</tr>
<tr>
<td>Pure ventricle</td>
<td>3 (5.08%)</td>
<td>3 (4.11%)</td>
</tr>
<tr>
<td>Traumatic</td>
<td>27 (45.76%)</td>
<td>32 (43.84%)</td>
</tr>
<tr>
<td>Cause of cerebral hemorrhage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertensive</td>
<td>23 (38.98%)</td>
<td>29 (39.73%)</td>
</tr>
<tr>
<td>Cerebrovascular malformation</td>
<td>9 (15.25%)</td>
<td>12 (16.44%)</td>
</tr>
</tbody>
</table>

Figure 2: Continued.
bleeding sites, bleeding high-signal shadows of different areas and sizes could be observed, but the display was not very clear and the resolution was not high. The signal display between the normal brain tissue was poor, and the boundary line was not clear.

3.3. CT Imaging Manifestations of Different Parts of the Cerebral Hemorrhage in Patients from the Experimental Group. The CT images of different sites of the cerebral hemorrhage in different patients from the experimental group during this study are shown in Figure 3. Besides, Figure 3(a) shows a CT image of one patient with cerebellar hemorrhage; Figure 3(b) shows a CT image of one patient with putamen hemorrhage; Figure 3(c) shows a CT image of one patient with hypothalamic hemorrhage; Figure 3(d) shows a CT image of one patient with ventricular hemorrhage. Through the observation of CT images of patients in the experimental group, it was found that the high and low signal display of this group of images was very obvious, the lesion site was also very clear, and the boundary between the lesion and the normal tissue was clear.

3.4. Subjective Scores and Grading of CT Images of the Cerebral Hemorrhage in the Two Groups. By sorting and counting the subjective score and grading of CT images of patients in the two groups by two physicians (Table 3), the score of the control group by physician A was 4.01 ± 0.23 points, and the score by physician B was 4.09 ± 0.33 points. The score results of the experimental group by physicians A and B were 4.34 ± 0.56 points and 4.52 ± 0.61 points in turn. There was no statistical significance in the comparison between the data in the two groups (P > 0.05) (Figure 4). After the Kappa test, the CT image quality scores of patients from the two groups by two physicians were consistent (Kappa value was 0.75 and 0.78, respectively), and there was no statistically marked difference in this comparison (P > 0.05). The average CT score of the two groups was 4.05 ± 0.28 points in the control group and 4.43 ± 0.59 points in the experimental group. There were 45 cases rated as excellent and 8 cases rated as good in the experimental group, so the excellent and good rate was 89.9% (53/59). In the control group, 38 cases were excellent and 10 cases were good, so the excellent and good rate was 65.8% (48/73). Through comparison, it was found that the excellent and good rate of grading in the experimental group was significantly higher than that in the control group (P < 0.05), and the quality of CT images in the experimental group was higher than that in the control group (Figure 5), suggesting that the diagnosticity of CT images reconstructed by SAFIRE algorithm was higher.

3.5. CT Imaging Manifestations and Objective Scores of the Cerebral Hemorrhage in Patients from the Two Groups. By sorting out and comparing the objective scores of the CT images of the two groups of patients, it was found that there were certain differences in the average CT values of the gray matter, white matter, and cerebral hemorrhage lesions of the two groups of CT images, but there was no marked difference (P < 0.05) (Figure 6). However, the SD, image SNR, and CNR results of gray matter, white matter, and cerebral hemorrhage lesions in the experimental group were better than those in the control group, and the differences were statistically significant (P < 0.05) (Figure 7).

4. Discussion
Cerebral hemorrhage, a common sudden disease in clinical practice, has the highest mortality rate in acute cerebrovascular diseases, and due to the frequent and recurrent nature of this disease, it is necessary to carry out CT examination repeatedly for the diagnosis and treatment of the disease [16]. Moreover, the diagnostic effect of CT on cerebral hemorrhage disorders has been investigated by many experts, and studies have concluded that CT can not only display the location range, size, and the number of lesions of
cerebral hemorrhage but also dynamically display lesions, providing an effective basis for clinical treatment of cerebral hemorrhage [17]. However, there is electrical radiation in the operation of CT inspection, and repeated CT scans in a short period have a great radiation risk, so the low-dose CT examination technology has become the focus of research in recent years [18,19]. Some experts have conducted relevant studies on the application of low-dose CT imaging technology in the examination of craniocerebral diseases, and the results reveal that low-dose CT scan can form a good contrast with the surrounding brain tissue, which provides a basis for the application of low-dose CT scan in the examination of cerebral hemorrhage [20]. Later, there have been some studies where experts have analyzed the

![CT images of different parts of the cerebral hemorrhage](image)

**Figure 3:** CT imaging manifestations of different parts of the cerebral hemorrhage in the experimental group. (a) Cerebellum, female, 50 years old. (b) Putamen, male, 43 years old. (c) Thalamus, male, 54 years old. (d) Ventricle, female, 57 years old.

<table>
<thead>
<tr>
<th></th>
<th>Experimental group ($n = 59$)</th>
<th>Control group ($n = 73$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa value</td>
<td>0.78</td>
<td>0.75</td>
</tr>
<tr>
<td>Subjective score (average value)</td>
<td>4.43 ± 0.59 points</td>
<td>4.05 ± 0.28 points</td>
</tr>
<tr>
<td>Grading</td>
<td>Unqualified 2</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Qualified 6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Good 8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Excellent 45</td>
<td>38</td>
</tr>
<tr>
<td>Excellent and good rate (%)</td>
<td>89.9$^*$</td>
<td>65.8$^*$</td>
</tr>
</tbody>
</table>

*Note.* $^*$The comparison is statistically significant ($P < 0.05$).
application of low-dose CT scanning in the detection of a cerebral hemorrhage. The results indicate that the low-dose CT scan can achieve the same effect as routine dose CT scan in the examination of patients with cerebral hemorrhage and is conducive to reducing the radiation impact on patients, so it has a good application value [8,21]. A recent meta-analysis has shown that, in the low-dose CT imaging of patients with atherosclerotic subarachnoid hemorrhage, if the radiation...
dose is reduced to 40% of the original dose level, the accuracy of the diagnosis of cerebral perfusion injury will not be affected [7]. However, some experts put forward that there is an exponential relationship between tube voltage and radiation dose, and reducing tube voltage can significantly reduce radiation dose, but at the same time increase image noise and reduce image quality [13,22]. Therefore, with the continuous improvement of multi-slice spiral CT technology, the SAFIR technology has been studied.

In this study, when low-dose CT scanning technology was used to examine patients with cerebral hemorrhage, SAFIR technology was employed to reconstruct CT images, and the results of routine low-dose CT scanning were compared for the diagnosis of the disease. The results disclosed that the average CT scores of patients in the two groups were 4.05 ± 0.28 points in the control group and 4.43 ± 0.59 points in the experimental group. The excellent and good rate of the experimental group was 89.9% (53/59), and the rate of the control group was 65.8% (48/73). Besides, the SD, image SNR, and CNR results of gray matter, white matter, and cerebral hemorrhage lesions in the experimental group were better than those in the control group, and the differences were statistically remarkable (P < 0.05), suggesting that low-dose CT images after reconstruction by SAFIR technology had more diagnostic significance. Some experts have conducted a preliminary study on the clinical application of low-tube voltage combined with iterative reconstruction technology in CT examination of patients with cerebral hemorrhage [23]. Low-dose CT scanning combined with SAFIRE for the diagnosis of lumbar disc herniation (LDH) has been studied, indicating that the image quality of low-dose CT scanning combined with SAFIR LDH examination is no less than that of the routine dose; compared with the routine-dose scanning, low-dose CT scanning does not affect the diagnostic effect, and it is in good agreement with clinical diagnosis results, which also has ideal application value [24]. There is also research that evaluates the image quality of Filtered Back Projection (FBP) and SAFIRE in the context of low radiation and low-contrast CT scanning in aorta examination. The results have indicated that 70 kV combined with SAFIR iterative reconstruction is feasible in the application of pulmonary artery CT angiography. SAFIR has lower noise than FBP and plays an important role in low-dose studies [25]. The above results are similar to the results of this study, showing the application advantages of SAFIR technology.

5. Conclusion

In this study, SAFIR technology combined with low-dose CT scanning technology was applied to scan patients with cerebral hemorrhage, and the image quality under the technology was compared with that under the low-dose CT scanning technology alone, to evaluate the application value of this combined technology in the diagnosis of cerebral hemorrhage. The results showed that the image quality of low-dose CT scan reconstructed by SAFIRE algorithm was better than that of low-dose CT scan, so that patients with cerebral hemorrhage could carry out diagnostic examination with guaranteed accuracy under the risk of low radiation and provide better imaging services for patients with cerebral hemorrhage. However, this research still has certain limitations, the comparison indicators are not perfect, and the research content is not very representative. Therefore, future research will be strengthened and improved. In addition, the application prospect of SAFIRE technology has been reflected to a certain extent.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

References


