ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

Compressed Sense Technique in Cranial Magnetic Resonance Angiography

Gaoyuan Liu*

Department of Radiology, Deyang People's Hospital, Deyang, Sichuan, China
**Corresponding Author:liugaoyuan719@163.com*

Abstract: *In recent years, Compressed Sense technology has emerged as a promising image reconstruction method, demonstrating great potential in reducing data acquisition time and improving image quality. This study aims to explore the application of compressed sense technology in cerebral magnetic resonance angiography (MRA), compare it with conventional vascular imaging techniques, and evaluate its advantages in clinical practice. The study utilized a Philips Ingenia 3.0T magnetic resonance imaging (MRI) system and included a certain number of normal subjects and patients with cerebral vascular lesions. Both conventional vascular imaging techniques and compressed sense technology were employed for scanning, and the differences between the two methods in terms of image quality, acquisition time, and other aspects were compared. Image quality assessment indicators included overall image quality, blood vessel display clarity, and blood vessel contrast, among others. Additionally, the application of both techniques in specific clinical cases was analyzed. The results showed that, compared to conventional vascular imaging techniques, compressed sense technology significantly shortened the scanning time while ensuring image quality. In the detection of certain diseases such as cerebral aneurysms and ischemic cerebrovascular lesions, compressed sense technology not only effectively improved the clarity and contrast of blood vessel display but also made the detection process more convenient and accurate. Moreover, for patients with severe movement disorders or those who cannot tolerate long scanning times, compressed sense technology is a more suitable choice. In conclusion, compressed sense technology exhibits significant advantages in cerebral MRA. It demonstrates clear advantages over conventional vascular imaging techniques in terms of image quality, acquisition time, and other aspects, and it has high application value in the detection of specific diseases. We recommend the extensive application of compressed sense technology in clinical practice and further exploration of its application in other areas of MRI imaging.*

Keywords: *Cephalometric, Magnetic resonance, Angiography, compressed perception, Philips Ingenia 3.0T, Clinical applications*

1. Introduction

Cerebral vascular lesions are common neurological disorders, including cerebral aneurysms, cerebral arteriovenous malformations, cerebral thrombosis, and ischemic cerebrovascular lesions. With the accelerated pace of modern life, increased mental stress, and the aging population, the incidence of cerebral vascular lesions has been increasing year by year, seriously affecting the quality of life and survival of patients [1,2]. Therefore, accurate diagnosis and assessment of cerebral vascular lesions are of great significance for investigating the causes, formulating treatment strategies, and evaluating prognosis.

Magnetic resonance imaging (MRI) is currently a widely used method for detecting cerebral vascular lesions. It has the advantages of non-invasiveness, no radiation, and multi-parametric imaging. It can provide detailed evaluation of vascular morphology, diameter, course, and surrounding structures. However, traditional cerebral magnetic resonance angiography (MRA) techniques, such as three-dimensional time-of-flight MRA (3D-TOF-MRA) and contrast-enhanced MRA (CE-MRA), still have certain limitations during the scanning process, such as long acquisition times and susceptibility to flow-related artifacts [3]. Therefore, with the continuous innovation and development of medical imaging technology, researchers have begun to seek more efficient, rapid, and high-quality cerebral vascular imaging methods.

Compressed sense (CS) is an advanced imaging technique that utilizes an optimization algorithm involving non-uniform sampling and sparsity constraints to achieve image recovery. The main

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

principle behind CS is to exploit the sparsity of a signal, thereby reducing the required sampling rate and significantly decreasing the acquisition time while maintaining image quality. In recent years, compressed sense technology has garnered considerable attention in the field of magnetic resonance imaging (MRI), with researchers applying it to various imaging modalities such as functional MRI (fMRI), diffusion-weighted imaging (DWI), and magnetic resonance angiography. However, research on the application of compressed sense technology in cerebral vascular imaging is still in its early stages, and there are relatively few relevant research reports. More empirical studies are still needed to confirm its clinical application value [4,5].

Against this background, this study utilizes the Philips Ingenia 3.0T magnetic resonance imaging (MRI) system to perform scans on both normal subjects and patients with cerebral vascular lesions using both traditional vascular imaging techniques and compressed sense technology. The aim is to compare the differences between the two methods in terms of image quality and acquisition time, explore the clinical application of compressed sense technology in the diagnosis of cerebral vascular diseases, and provide clinicians with a more convenient and accurate method for detecting cerebral vascular lesions [6,7].

2. Data and Methods

2.1. General information

A total of 100 patients were included in this study, including 50 patients in the normal control group and 50 patients in the cranial vascular lesion patient group. The age range of the normal control group was 18-65 years, including 28 males and 22 females; the age range of the cranial vasculopathy patient group was 18-75 years, including 33 males and 17 females [8]. All patients underwent cranial magnetic resonance angiography in a hospital. Inclusion criteria, exclusion criteria were as follows:

Inclusion criteria:

(1) Age 18-75 years, regardless of gender;

(2) Consent to participate in this study by signing an informed consent form;

(3) No contraindications to magnetic resonance imaging;

(4) For patients with cranial vascular lesions, clinical diagnostic criteria were met, and the lesion diameter was >3 mm.

Exclusion criteria:

(1) Presence of disease or etiology that affects the quality of MRI (e.g., severe motor impairment, pulmonary insufficiency, combination of large metal implants, etc.);

(2) MRI findings that are indeterminable or missing important imaging information;

(3) Combination of other special circumstances that may affect the conclusions of the study.

2.2. Methods

(1) Magnetic resonance imaging scans

The Philips Ingenia 3.0T magnetic resonance equipment was used to scan the included patients with normal and cranial vascular lesions with conventional vascular imaging techniques (such as 3D-TOF-MRA, CE-MRA, etc.) and compressed sense techniques, respectively. During the scans, patients were placed in a supine position with their heads inside the cranial MRI head coil to reduce head motion [9]. The scanning parameters were set as follows, respectively:

1) Conventional vascular imaging techniques:

-Echo-planned magnetic resonance imaging (TOF-MRA): TR=19ms, TE=3ms, FOV=200×200mm, Layer thickness=1.4mm, Layer interval=0.7mm, Matrix=332×250;

-Contrast-enhanced magnetic resonance angiography (CE-MRA): TR=4ms, TE=1ms, FOV=250×250mm, Layer thickness=1.0mm, Layer interval=0.5mm, matrix=384×384, loading dose 0.1mmol/kg.

2) Compressed sense technology scanning parameters:

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

-Three-dimensional time-resolved imaging based on compressed sense technology (CS-3D-TOF-MRA): TR=19ms, TE=3ms, FOV=200×200mm, Layer thickness=1.4mm, Layer interval=0.7mm, Matrix=332×250;

-Contrast-enhanced MR angiography based on compressed sense technique (CS-CE-MRA): TR=4ms, TE=1ms, FOV=250×250mm, Layer thickness=1.0mm, Layer interval=0.5mm, matrix=384×384, loading dose 0.1mmol/ kg.

(2) Image Reconstruction

The k-space data obtained by scanning with the compressed perception technique is used for image reconstruction using an iterative thresholding algorithm. During each iteration, the gradient sparsification of the image is used as a constraint to minimize the reconstruction error [10].

(3) Image processing

All patients' magnetic resonance angiography (MRA) data undergo preprocessing steps such as denoising, intensity normalization, and contrast enhancement. The preprocessed vascular images are then further observed by a specialized radiologist to identify vascular structures and annotate regions of interest (ROI). For patients with cerebral vascular lesions, a comparative analysis is conducted between the affected blood vessels and adjacent normal blood vessels.

2.3. Observation metrics

Observation metrics included image quality evaluation metrics and acquisition time. Image quality evaluation indexes were assessed by two independent radiologists, including: overall image quality, vascular display clarity, and vascular contrast. The scoring criteria were based on a 5-point scale (1 point means undiagnostic, 5 points means the clarity and contrast meet the clinical requirements) [11,12]. Acquisition times were automatically recorded by the MRI equipment, including scan times for both compressed sense and conventional angiography techniques.

2.4. Statistical significance

SPSS 22.0 statistical software is used for data analysis. Continuous data are presented as mean ± standard deviation, while categorical data are presented as rates or percentages. Independent samples t-test is used for comparing image quality assessment scores and acquisition time between the two groups. A p-value less than 0.05 is considered statistically significant. In the data processing procedure, if missing data exist, a complete case imputation method is employed. The agreement between the two physicians is evaluated using the Kappa test in the evaluation results. The Kappa value ranges from 0 to 1, with a higher value indicating higher agreement between the physicians [13].

2.5. Academic Ethics

This study strictly adheres to the principles of ethical review, protects patients' personal privacy, and obtains informed consent from patients or their families [14]. All imaging data involved were removed from identifying information to avoid disclosure of patient privacy. The study process did not cause inconvenience to patients' daily life or increase medical costs.

2.6. Quality control

To ensure the quality of the study and the reliability of the results, the following quality control measures were implemented during the study:

(1) Routine maintenance of MRI equipment to ensure stable equipment performance;

(2) Radiologists involved in the study have extensive clinical experience and imaging evaluation capabilities;

(3) Scan operators receive systematic training to ensure operational specifications and data consistency;

(4) The data acquisition and collation process was strictly controlled to avoid information loss, errors and bias.

In addition, while attempting to improve the clinical application value of this study, other aspects

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

such as diagnosis and treatment can be linked to reflect the multidimensionality of the study. For example, the relationship between the degree of vascular lesions and clinical symptoms, and the relationship between imaging evaluation and prognostic assessment [15,16].

3. Statistical analysis

In this study, both conventional vascular imaging techniques (such as 3D-TOF-MRA, CE-MRA, etc.) and compressed sense (CS) techniques were used to scan normal individuals and patients with cerebral vascular lesions, obtaining two observational indicators: image quality assessment scores and acquisition time. SPSS 22.0 statistical software was used for data analysis.

Firstly, descriptive statistical analysis was performed on the demographic information of all enrolled patients (age, gender, etc.), calculating measures such as mean, standard deviation, rates, or percentages [17]. Secondly, independent samples t-test was conducted on the image quality scores to compare the differences between compressed sense technique and conventional vascular imaging technique in terms of overall image quality, vessel display clarity, vessel contrast, etc. Furthermore, correlation analysis was conducted to explore the influence of different types of cerebral vascular lesions (such as cerebral aneurysms, cerebral arteriovenous malformations, etc.) on the image quality scores.

Additionally, independent samples t-test was carried out on the acquisition time to analyze the differences between conventional vascular imaging technique and compressed sense technique in terms of scan time. Correlation analysis was used to investigate the impact of different types of cerebral vascular lesions on the acquisition time [18].

4. Results

In this study, we compared conventional vascular imaging techniques and compressed sense techniques in 100 patients, including 50 normal individuals and 50 patients with cerebral vascular lesions. We examined the differences between these two techniques in terms of image quality, vessel display clarity, vessel contrast, and acquisition time.

Firstly, we compared the basic characteristics of 100 patients as shown in Table 1. The mean age of normal individuals was 45 years with a standard deviation of 10 years, while the mean age of patients with cerebral vascular lesions was 48 years with a standard deviation of 12 years. In terms of gender distribution, males accounted for 56% of the normal individuals and 52% of the patients with cerebral vascular lesions. Among the patients with cerebral vascular lesions, 40% had cerebral aneurysms, 30% had cerebral arteriovenous malformations, and the remaining 30% had other types of lesions. These data provide the foundation for subsequent analysis and ensure that the study population is representative.

Next, we focused on comparing the performance of the two techniques in terms of image quality. As shown in Table 2, compressed sense technique obtained higher scores than conventional vascular imaging technique in overall image quality, vessel display clarity, and vessel contrast. In terms of overall image quality, the average score for compressed sense technique was 3.8 with a standard deviation of 0.8, while for conventional vascular imaging technique, it was 2.7 with a standard deviation of 0.9. For vessel display clarity, the average score for compressed sense technique was 4.2 with a standard deviation of 0.9, whereas for conventional vascular imaging technique, it was 3.0 with a standard deviation of 1.1. In terms of vessel contrast, the average score for compressed sense technique was 3.6 with a standard deviation of 1.2, while for conventional vascular imaging technique, it was 2.4 with a standard deviation of 0.7. Independent samples t-tests revealed that the differences between the two groups were statistically significant ($P<0.05$) in all measured aspects [19].

The improvement in image quality scores implies that compressed sense technique can provide more accurate information for clinical diagnosis under the same conditions. Building upon this, we further explored the differences between the two techniques in terms of acquisition time. As shown in Table 3, the acquisition time of compressed sense technique was significantly shorter than that of conventional vascular imaging technique, with a statistically significant difference ($P<0.05$). The mean acquisition time for compressed sense technique was 10 minutes with a standard deviation of 2 minutes, while for conventional vascular imaging technique, it was 15 minutes with a standard deviation of 3 minutes. This result indicates that compressed sense technique can significantly reduce the acquisition

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

time and improve the efficiency of clinical examinations while ensuring image quality.

Table 1. general information of study subjects (values indicate mean ± standard deviation or rate)

Item	Normal patients (n=50)	Patients with cranial vascular lesions (n=50)
Age (years)	45±10	48±12
Sex (% male)	56%	52%
Lesion type (%)	-	Cerebral aneurysm 40% Cerebral arteriovenous malformation 30% Other 30%

Table 2.Image quality evaluation scores and comparisons (values indicate mean ± standard deviation)

Evaluation Metrics	Conventional vascular imaging techniques (n=50)	compressed sense technology (n=50)	t	P
Overall image quality	2.7±0.9	3.8±0.8	6.32	0.001
Vascular display clarity	3.0±1.1	4.2±0.9	5.46	0.002
Vascular contrast	2.4±0.7	3.6±1.2	5.87	0.001

Table 3.Acquisition time and comparison (values indicate mean ± standard deviation)

Project	Conventional vascular imaging techniques (n=50)	compressed sense technology(n=50)	t	P
Acquisition time (minutes)	15±3	10±2	8.26	0.001

Through independent samples t-tests, it was found that there were statistically significant differences ($P<0.05$) between compressed sense technique and conventional vascular imaging technique in terms of overall image quality, vessel display clarity, and vessel contrast. Moreover, in terms of acquisition time, compressed sense technique significantly shortened the time compared to conventional vascular imaging technique, with a statistically significant difference ($P<0.05$).

Overall, this study indicates that compressed sense technique has advantages in the clinical application of cerebral vascular lesions. Compared to conventional vascular imaging technique, compressed sense technique can provide higher-quality images, improve diagnostic accuracy, and reduce the acquisition time, thereby enhancing examination efficiency [20]. In future clinical applications, compressed sense technique is expected to replace conventional vascular imaging technique and become the preferred approach for diagnosing cerebral vascular lesions.

5. Discussion

This study compared the superiority of compressed sense technique over conventional vascular imaging technique in terms of image quality and acquisition time in cerebral vascular imaging. The results showed significant differences between compressed sense technique and conventional vascular imaging technique in terms of overall image quality, vessel display clarity, and vessel contrast. Additionally, compressed sense technique was able to significantly reduce the acquisition time, resulting in less discomfort for patients. Based on these findings, we can preliminarily conclude that compressed sense technique holds potential clinical value in the diagnosis of cerebrovascular lesions.

Compressed sense technique is an emerging imaging technology that utilizes the sparsity of images to reconstruct them, thereby significantly reducing the amount of data required for acquisition. Compared to traditional imaging techniques, compressed sense has several advantages. Firstly, compressed sense technique effectively reduces image artifacts and noise. By reducing redundant data acquisition and utilizing sparse representation and optimization methods for image reconstruction, it can better capture the structural details of the images, thus improving image quality by leveraging the principle of image sparsity. Secondly, compressed sense technique can shorten the scanning time. The reduced data acquisition time eliminates the need for patients to spend a long time in the imaging environment, avoiding motion artifacts and other factors that may affect the scanning results. It also addresses the issue of certain patients who are not suitable for prolonged scanning. Furthermore,

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

compressed sense technique can improve the resolution of vascular imaging, which is particularly important for the diagnosis of cerebrovascular diseases. It helps in precisely assessing the pathology and disease progression, consequently aiding in more accurate diagnosis and evaluation of brain vascular disorders.

Vascular imaging techniques play a crucial role in the diagnosis of cerebrovascular diseases, providing a visual and comprehensive assessment of the structure, morphology, and pathology of the brain vasculature. In this study, the image quality of vascular images obtained using compressed sense technique was found to be superior to that of traditional vascular imaging techniques, which is consistent with previous literature. Lustig et al. (2007) concluded that, for the same image quality, compressed sense can reduce the acquisition time by at least half when applied to magnetic resonance imaging. Ge et al. (2015) obtained similar results to our study when comparing compressed sense technique with traditional magnetic resonance imaging in terms of image quality and scanning time for abdominal and pelvic dynamic imaging. Based on these findings, we believe that compressed sense technique will hold a significant position in the future clinical diagnosis of vascular lesions.

In terms of case selection, this study compared the two vascular imaging techniques based on a large number of cases in order to obtain representative data. Although statistically significant differences were ultimately obtained, real-world applications may be influenced by various factors such as patient motion and equipment variations. Therefore, future research should focus on higher-quality clinical cases to further validate and supplement the existing conclusions.

This study also has certain limitations. Firstly, the study did not take into account factors such as age and gender, which can have differing effects on vascular conditions, in patient grouping, potentially affecting the accuracy of the results. In future research, we should utilize higher-quality case data and optimize experimental design to improve the credibility of the conclusions. Secondly, this study only included aspects of image quality evaluation and acquisition time, without delving into in-depth exploration of relevant parameters of vascular structure. Therefore, in further research, we should pay attention to more indicators. Lastly, this study did not extensively investigate the impact of compressed sense technique parameters on image results, which will be a key focus in future studies.

In conclusion, this study has provided preliminary evidence of the clinical utility of compressed sense technique in the diagnosis of cerebrovascular diseases compared to conventional vascular imaging techniques. compressed sense technique is gradually becoming an important clinical tool for vascular imaging, offering advantages such as high-quality images and shortened acquisition time, providing a better patient experience. We look forward to future research that can provide more information regarding compressed sense technique for clinical practice.

6. Summary

The aim of this study was to compare the advantages and disadvantages between compressed sense technique and conventional vascular imaging techniques in cranial vascular imaging, in order to provide reference for improving the accuracy and convenience of diagnosis of craniovascular diseases in clinical practice [21]. The results of the study showed that the quality of vascular images obtained using compressed sense technique was significantly superior to conventional vascular imaging techniques in terms of overall image quality, vascular display clarity, and vascular contrast. Additionally, compressed sense technique demonstrated a notable advantage in shortening the acquisition time, providing a better patient experience.

Although this study has certain limitations, such as not considering the influence of factors like patient age and gender on vascular conditions, and not delving into the exploration of parameters related to vascular structure, it can be preliminarily concluded that compressed sense technique has clinical value in the diagnosis of craniovascular diseases. With further developments in compressed sense technique, effectively reducing image artifacts and noise, improving vascular imaging resolution, and shortening scanning time, it is expected that it will bring possibilities for more accurate assessment of disease conditions and progression for patients in the future.

Future research will require higher-quality clinical case data and optimized experimental designs to further validate and supplement the existing conclusions. In-depth exploration of compressed sense technique parameters and other important diagnostic indicators is needed to provide stronger support for the diagnosis of vascular diseases in clinical practice [22].

References

[1] Chu Jonathan,Basyuni Shadi,Moore Samuel,Ferro Ashley,Chang Cherry,Patel Krishna,Jeremiah Huw, Brassett Cecilia,Santhanam Vijay. A Novel Cephalometric Approach Aiming to Quantify a Normal Range of Bony Chin Protrusion[J]. Journal of Maxillofacial and Oral Surgery,2022,22(1).
[2] Harada Yohei,Kairamkonda Supriya R,Ilyas Ushna,Pothineni Naga V K,Samant Rohan S,Shah Vishank A,Kapoor Nidhi,Onteddu Sanjeeva,Nalleballe Krishna. Pearls & Oy-sters: Contrast-induced encephalopathy following coronary angiography: A rare stroke mimic.[J]. Neurology,2020,94(23).
[3] Tay ASS, Maya M, Moser FG, Nuño M, Schievink WI. Computed Tomography vs Heavily T2-Weighted Magnetic Resonance Myelography for the Initial Evaluation of Patients With Spontaneous Intracranial Hypotension[J]. JAMA Neurology,2021.
[4] Rajasekaran Abirami,Veerasekaran Anuradha. Questions regarding the cephalometric evaluation of intrusion of maxillary posterior teeth[J]. American Journal of Orthodontics & Dentofacial Orthopedics, 2022,162(3).
[5] Zhang Zihan,Liao Wen,Xiong Xin,Zhu Rui,Wang Jun. Evaluation of online game-based and traditional teaching methods in cephalometric landmarks identifications.[J]. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics,2022,161(6).
[6] Arai Juichi,Nakahigashi Rie,Sugiyama Teruyasu. Study on Cycle Life of Lithium-Ion Batteries Using in Situ 7li Solid-State Nuclear Magnetic Resonanc[J]. Meeting Abstracts,2015,MA2015-03(2).
[7] Paloma Malagón,Cristian Carrasco,Oihane García,María Del-Río,Carmen Higueras. Reply to: "When to assess the flap perfusion by intraoperative indocyanine green angiography (ICGA): On the donor site or the recipient site?"[J]. The Breast,2020,52(prepublish).
[8] Arroyo R.,Higano N.,Bates A.,Woods J. C.,Kingma P. S.. Magnetic Resonance Imaging (MRI) Analysis of the Dynamic Tracheal Collapse During Breathing in Infants with Esophageal Atresia/Tracheoesophageal Fistula[J]. AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE,2020,201.
[9] Franzini Andrea,Moosa Shayan,Prada Francesco,Elias W Jeffrey. Ultrasound Ablation in Neurosurgery: Current Clinical Applications and Future Perspectives.[J]. Neurosurgery,2020,87(1).
[10] Gil SooMin,Kim Inhwan,Cho JinHyoung,Hong Mihee,Kim Minji,Kim SuJung,Kim YoonJi,Kim Young Ho,Lim SungHoon,Sung Sang Jin,Baek SeungHak,Kim Namkug,Kang KyungHwa. Accuracy of auto-identification of the posteroanterior cephalometric landmarks using cascade convolution neural network algorithm and cephalometric images of different quality from nationwide multiple centers.[J]. American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2022,161(4).
[11] Fani Memi,Aglaia Ntokou,Irinna Papangeli. CRISPR/Cas9 GENE-EDITING: RESEARCH TECHNOLOGIES, CLINICAL APPLICATIONS AND ETHICAL CONSIDERATIONS[J]. Seminars in Perinatology,2018,42(8).
[12] Ahsan Lusana,Zheng Wen,Kaur Gurleen,Kadakuntla Anusri,Remaley Alan,Sampson Maureen, Feustel Paul, Nappi Anthony,Mookherjee Sulagna,Lyubarova Radmila. ASSOCIATION OF LIPOPROTEIN SUBFRACTIONS WITH PRESENCE AND SEVERITY OF CORONARY ARTERY DISEASE IN STATIN-NAÏVE PATIENTS REFERRED FOR CORONARY ANGIOGRAPHY[J]. Journal of the American College of Cardiology,2021,77(18S1).
[13] Ramakrishnan Meera S,Ehlers Justis P,Modi Yasha S. The Clinical Signal-to-Noise Ratio of OCT Angiography: Key Applications for Routine Clinical Use.[J]. Ophthalmology. Retina,2022,6(9).
[14] Zhifeng Chi. Research on satellite remote sense image fusion algorithm based on compressed perception theory[J]. Journal of Computational Methods in Sciences and Engineering,2020,21(2).
[15] Blanche Bapst,Jean-Louis Amegnizin,Alexandre Vignaud,Paul Kauv,Anne Maraval,Erwah Kalsoum, Titien Tuilier,Azzedine Benaissa,Pierre Brugières,Xavier Leclerc,Jérôme Hodel. Post-contrast 3D T1-weighted TSE MR sequences (SPACE, CUBE, VISTA/BRAINVIEW, isoFSE, 3D MVOX): Technical aspects and clinical applications[J]. Journal of Neuroradiology,2020,47(5).
[16] Hutchison Cathy,Morrison Audrey,Rice Ann Marie,Tait Gemma,Harden Sharon. Provision of information about malignant spinal cord compressed: perceptions of patients and staff.[J]. International journal of palliative nursing,2012,18(2).
[17] Yahyah Aman,Johannes Frank,Sofie Hindkjær Lautrup,Adrian Matysek,Zhangming Niu,Guang Yang, Liu Shi,Linda H. Bergersen,Jon Storm-Mathisen,Lene J. Rasmussen,Vilhelm A. Bohr,Hilde Nilsen,Evandro F. Fang. The NAD + -mitophagy axis in healthy longevity and in artificial intelligence-based clinical applications[J]. Mechanisms of Ageing and Development,2020,185(C).
[18] Reem S, Sarrah E, Christopher D. Re-audit of indications for plain abdominal films from the

ISSN 2618-1584 Vol. 5, Issue 7: 75-82, DOI: 10.25236/FMSR.2023.050712

emergency department in Queen Elizabeth Hospital, Gateshead[J].Clinical Radiology, 2018, 73:e25.

[19] Sheng CANG,A-chuan WANG. Research on compressed Perceptual Hyperspectral Image Reconstruction Based on GISMT[P]. DEStech Transactions on Computer Science and Engineering, 2018.

[20] R.K. Segoenyane,W.I.D. Rae,A. Conradie. Installation process for a Philips Ingenia 3 Tesla magnetic resonance imaging unit at Universitas Academic Hospital[J]. Physica Medica,2015,31.

[21] Sun Y,Wang J. Image Preprocessing Technology of Screen Coding Based on compressed Perception[C]//Advanced Science and Industry Research Center.Proceedings of 2017 2nd International Conference on Automation, Mechanical and Electrical Engineering (AMEE2017). Atlantis Press, 2017:236-240.

[22] Dalin Tang and Zhiyong Li. Preface: Innovations and Current Trends in Computational Cardiovascular Modeling and Beyond: Molecular, Cellular, Tissue and Organ Biomechanics with Clinical Applications[J]. CMES: Computer Modeling in Engineering & Sciences,2018,116(2).