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# Application of PDSA Circulation in Carotid Artery Ultrasound Screening for High-Risk Individuals with Stroke

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**Abstract:** *Objective* To explore the application effect of PDSA circulation in improving the quality of carotid artery ultrasound screening in high-risk populations for stroke. *Methods* Refer to PDSA cycle, Randomly select 600 image and text reports (including images and text descriptions) of carotid artery ultrasonic examination from January 2021 to December 2021 in the ultrasonic medical image information system, scored according to the quality scoring standard; The goal of this time is to achieve more than 95% of the reports of Class A image and texts, propose solutions to the problems of image quality and text description in the report. Formulate countermeasures from May to June 2021. Take 50 carotid ultrasound image and text reports after implementing various improvement measures from November 2021 to December 2021 for scoring, compare the differences between 2022 and 2021 ultrasonic image text reports and clinical satisfaction scores. Analyze the changes of image text reports and clinical satisfaction scores before and after the implementation of PDSA cycle, and continuously optimize the carotid ultrasound examination process through training and learning, discussion within the department, and collection of clinical feedback. *Result* Before implementing the PDSA process of standardized medical quality management, the score of carotid ultrasound image and text reports was (87.46±5.82), the clinical satisfaction was (84.46±6.42), and the number of A-class image and text reports accounted for 58% (348/600); After the implementation of the standardized medical quality management PDSA process, the score of graphic reports increased to (92.74±3.55) points, and the clinical satisfaction increased to (93.14±3.86) points. The number of Class A graphic reports accounted for 82% (492/600), with statistically significant differences (all $P$<0.05). *Conclusion* PDSA circulation has effectively improved the image and text report of carotid ultrasound screening and clinical satisfaction score, which can be applied to the quality control of other single diseases in the ultrasound department, so as to improve the medical quality of the ultrasound department.

**Keywords:** Ultrasound, Quality Assurance, PDSA Cycle, Carotid

## 1. Introduction

Professor Jiang Yuxin proposed [1] that it is increasingly urgent to continuously improve the quality of ultrasound medicine, promote the high-quality development of ultrasound medicine, strengthen the construction of ultrasound medicine talent team, and enhance the quality and standardization of ultrasound medicine in medical institutions at all levels nationwide. With the initial results of early screening and intervention projects for high-risk groups of stroke in China, our hospital, as a grassroots stroke prevention and control center, has seen a significant increase in clinical demand for stroke ultrasound screening. Vascular ultrasound is an important examination method for evaluating and diagnosing carotid artery lesions, which can accurately locate cervical blood vessels and perform segmental measurements of various blood flow parameters. Standardized ultrasound scanning and measurement, image data collection, and diagnostic analysis processes that comply with standardized quality control (hereinafter referred to as quality control) are the foundation of clinical applications. In order to improve the ultrasound screening ability of stroke in our department, our quality control team has decided to use the quality management tool PDSA cycle to control the quality of carotid artery ultrasound screening graphic and

textual reports and clinical satisfaction scores as ultrasound single disease types, in order to provide reference basis for early intervention of high-risk groups at the grassroots level. This study mainly explores the application effect of PDSA circulation in improving the quality of carotid artery ultrasound screening in high-risk populations of stroke at the grassroots level.

# 2. Materials and Methods

### *2.1. Object*

Randomly select 600 images and text reports of carotid artery ultrasound examination from January 2021 to December 2021, and from January 2022 to December 2022 in the Medical Imaging and Communication Systems (PACS), and score them according to quality control standards. Analyze the changes in carotid artery ultrasound image and text reports and clinical satisfaction data before and after the implementation of PDSA cycle.

### *2.2. Methods*

#### *2.2.1. Plan (P)*

Refer to the 4 stages and 8 steps in the PDCA cycle process [2]. From November to December 2022, our department established a stroke ultrasound screening quality control group, led by the department director. Referring to the "Guidelines for Chinese Stroke Vascular Ultrasound Examination", we formulated 10 ultrasound report and image quality control scoring standards, with a maximum score of 100 points. Analyze 600 carotid artery ultrasound image and text reports (including image quality and text description) from January 2021 to December 2021. Quality control personnel will comprehensively score the image quality and text description according to the guidelines for carotid artery examination (Table 1). A total score of ≥ 90 is classified as a Class A report, a score of 80-90 is classified as a Class B report, and a score of<80 is classified as a Class C report. After statistics, it was found that there were 348 Class A graphic and textual reports, 168 Class B reports, and 84 Class C reports before implementing the standardized medical quality management PDSA process. The quality control team analyzed the prominent issues in the B-class and C-class ultrasound image and text reports, classified and displayed them using fishbone images (Figure 1), and created a Plato (Figure 2) to analyze the collected data and determine the reasons for non-compliance. The discussion focuses on improving the quality of ultrasound images, textual descriptions, and clinical satisfaction. The goal of this meeting is to have over 95% of Class A graphic and textual reports, and to propose solutions to existing problems. The main reasons for the substandard image and text reports analyzed are: insufficient training on carotid artery ultrasound examination and instrument adjustment in the department, lack of development of carotid artery ultrasound examination process and image storage standards, resulting in arbitrary examination process, non-standard text description, and inconsistent diagnostic standards among physicians in the department. The main reasons for the substandard image and text reports analyzed are: insufficient training on carotid artery ultrasound examination and instrument adjustment in the department, lack of development of carotid artery ultrasound examination process and image storage standards, resulting in arbitrary examination process, non-standard text description, and inconsistent diagnostic standards among physicians in the department. The evaluation indicators include: (1) The ultrasound image and text description are comprehensively evaluated by the head of the ultrasound vascular professional group on image quality, report format, ultrasound description, and ultrasound prompt accuracy; (2) Obtain clinical satisfaction by distributing feedback questionnaires to clinical departments.

#### *2.2.2. Do (D)*

(1) Repeatedly organize general practitioners to study the “Expert Consensus on Quality Management Control Indicators for Ultrasound Medicine (2018 Edition)” and “Guidelines for Chinese Stroke Vascular Ultrasound Testing (2021 Edition)” multiple times. The leader of the vascular professional team will analyze the key points, collect relevant literature for special lectures, and provide training on instrument parameter adjustment. Hold a quality control meeting every month to jointly analyze non-standard images and text descriptions, and the team leader will provide guidance and comments. (2) Develop a procedure for carotid artery ultrasound examination and a standard section storage standard, specifically: when measuring carotid artery intima-media thickness, local magnification is necessary; The included angle between the sound beam and the blood flow is ≤ 60 ° when measuring the arterial blood flow spectrum; Measurement of plaque size and length (mm) × Thickness (mm) describes the largest responsible plaque measured when multiple plaques are present. When the diagnosis of carotid artery stenosis rate is ≥ 50%, measure the residual diameter of the stenosis artery and the original diameter, as well as the frequency spectrum of the stenosis segment and distal segment of the artery. Color Doppler and power Doppler were used to differentiate incomplete occlusion from completeness occlusion. Retain important positive and negative images. (3) Optimize the existing carotid ultrasound report template, including describing the carotid intima-media thickness, internal and common carotid artery diameters, blood flow velocity and spectral morphology of each segment. When discovering plaques, it is necessary to describe their location, size, surface integrity, and internal echogenicity. Ultrasound prompts should include localization, qualitative analysis, and grading of carotid artery stenosis [3]. (4) If encountering difficult or rare diseases during the examination process, it is necessary to promptly consult with a higher-level physician. (5) Follow up cases with a carotid artery stenosis rate of ≥ 50%. (6) Under the organization of the medical department, communicate the current status of ultrasound examination with clinical practice, participate in

monthly clinical stroke quality control meetings, investigate clinical satisfaction, promptly discuss feedback issues within the department, and develop improvement plans.

***Table 1.*** *Scoring indicators of carotid artery ultrasound image and text report.*

| Scoring indicators | Scoring instructions | Scoring criteria (out of 100 points) | Total (points) |
|---|---|---|---|
| Image quality | (1) Measure the intima-media thickness (IMT) in a longitudinal section within a range of 1.0 to 1.5 cm below the bifurcation level of the bilateral common carotid arteries. The bifurcation point is displayed in the longitudinal section of the bilateral external carotid arteries, and the common carotid artery is displayed in the longitudinal section of the bilateral internal carotid arteries. IMT is the vertical distance between the upper edge of the posterior wall intima and the upper edge of the outer membrane. Local magnification is necessary for image preservation;(2) Color Doppler ultrasound was used to detect the peak systolic velocity (PSV) and end diastolic velocity (EDV) of bilateral common carotid arteries (CCA) and internal carotid arteries (ICA) in the longitudinal section of external carotid arteries (ECA). The angle between the sound beam and the blood flow was ≤ 60 °, which must be stored;(3) The origin of the unnamed artery must have a map;(4) For ICA with stenosis ≥ 50%, measure the maximum flow velocity in the stenosis segment and the flow velocity in the distal stenosis segment; (5) With body surface markers or text markers | (1) 10 points for each item, no points will be given if no map is saved; (2) Deduct 1-10 points for non-standard stored images; (3) Deduct 1-10 points for any errors or omissions in the image | 50 |
| Report writing | (1) Symmetry of bilateral homonymous artery diameter, IMT, and blood flow velocity;(2) Atherosclerotic plaque shall describe the position and size of the plaque [in mm] × Thickness (mm) description], echo characteristics (homogeneous or heterogeneous echoes), and multiple (≥ 2/individual) plaques measure the largest responsible plaque;(3) Measurement of stenosis lumen (residual lumen and original lumen), maximum flow velocity in the stenosis segment and flow velocity in the distal stenosis segment;(4) There are no errors in words, orientation, numerical values or units, or image annotations, and the selected images in the report are representative; (5) Ultrasound prompts include localization, qualitative, quantitative (stenosis degree), sufficient diagnostic basis for lesions, accurate conclusions, and clear priorities. | (1) Deduct 10 points for missing one item;(2) 1-5 points will be deducted for each incorrect format, unclear organization, or unclear sentence; (3) Deduct 1-5 points for incorrect or non-standard report selection;(4) Deduct 5-10 points for any significant error. | 50 |

### *2.2.3. Study (S)*

Randomly inspect 600 carotid artery ultrasound examination graphic and textual reports after the implementation of PDSA circulation from January 2022 to December 2022, Analyze graphic reports and clinical satisfaction scores, The proportion of Class A reports reached 82% (492/600), which is still a certain gap from the set target (95%). The measurement of narrow segment and distal flow velocity reaches 92%, The image quality has significantly improved (Figures 3, 4), the text description is clear and standardized. There are still some problems such as too small images, incomplete labeling, and no display of diastole blood flow.

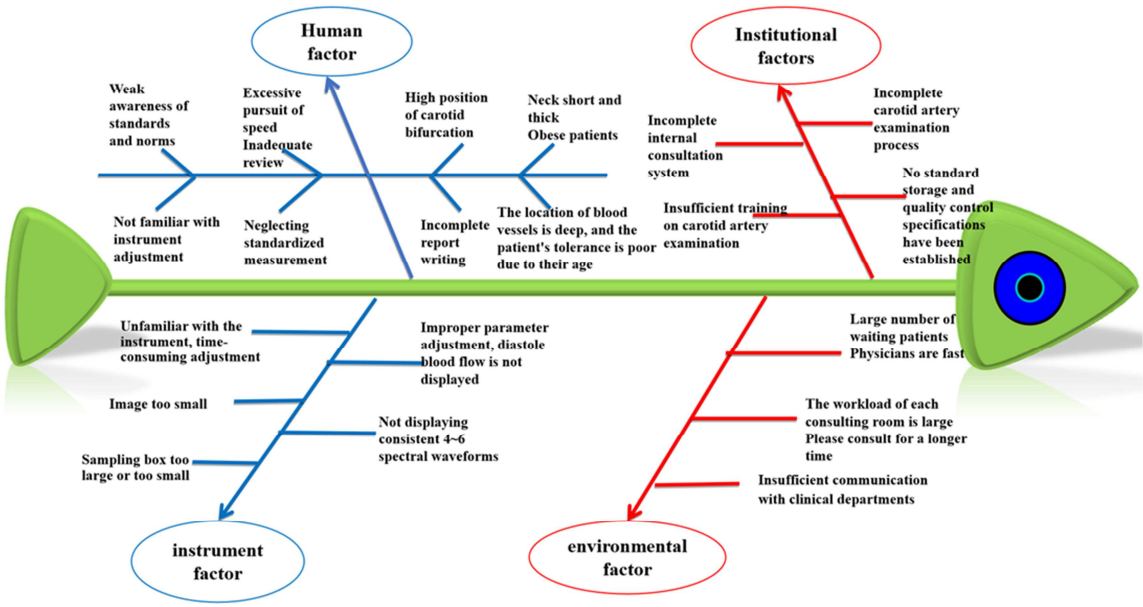


***Figure 1.*** *Fishbone image of carotid artery ultrasound image quality and reasons for substandard text description.*

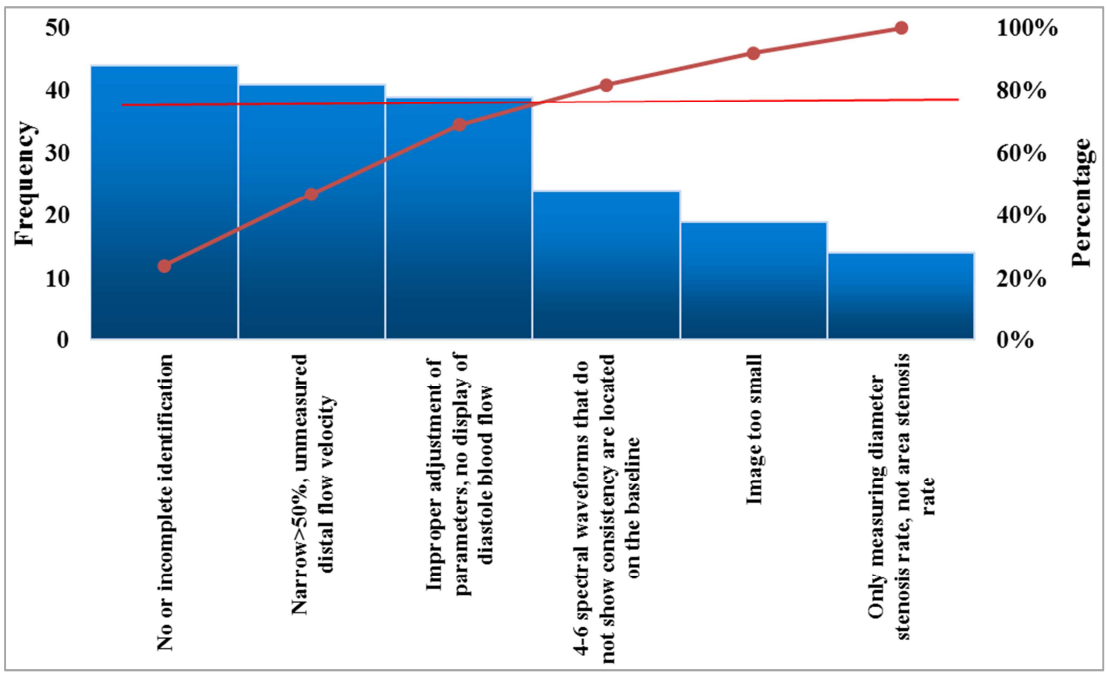


***Figure 2.*** *Plato of the reasons for unsatisfactory image quality and textual description of carotid artery ultrasound.*

#### *2.2.4. Action (A)*

(1) The comprehensive evaluation of the entire carotid artery, especially the hemodynamic detection in the middle and far segments, is recommended to use a combination of high and low frequency probes to accurately determine the presence of occlusive lesions; (2) Comprehensively adjust the instrument's vascular detection conditions, observe the morphology and internal acoustic characteristics of plaques from multiple perspectives, and objectively determine the stability of plaques; (3) Guide doctors to conduct reasonable triage based on the equipment and medical qualifications of each consulting room, and maintain good medical order; (4) Add carotid ultrasound quality management to the department quality control report, analyze and evaluate quality control results on a monthly basis, develop corresponding assessment systems, and guide general practitioners to meet quality control requirements.

### *2.3. Statistical Processing*

Apply SPSS 26.0 statistical software, The measurement data conforming to the normal distribution are expressed in $\bar{x} \pm s$, using non parametric testing; the counting data is expressed in examples or percentages (%). $P$<0.05 indicates a statistically significant difference.

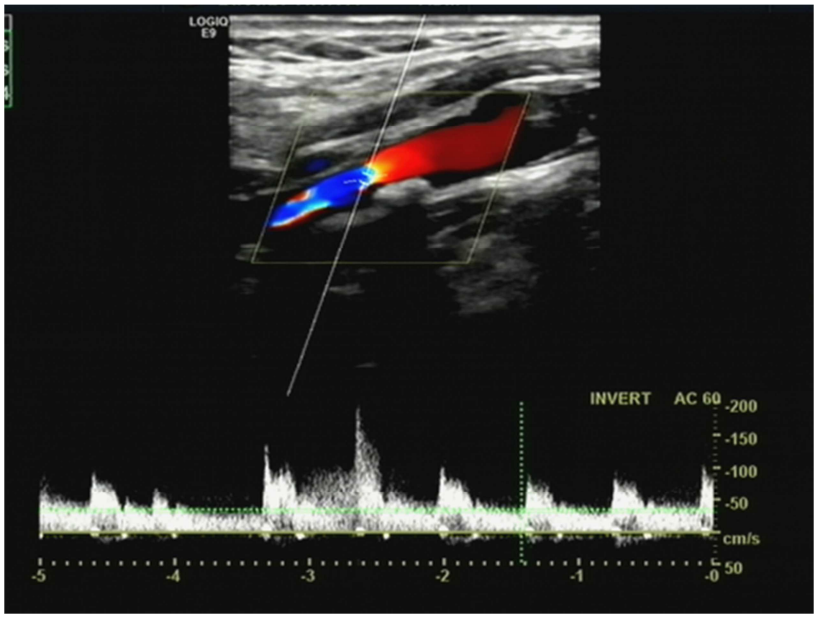


***Figure 3.*** *Blood flow spectrum of internal carotid artery stenosis segment before implementation (image without identification, unclear spectral edges, inconsistent waveform).*

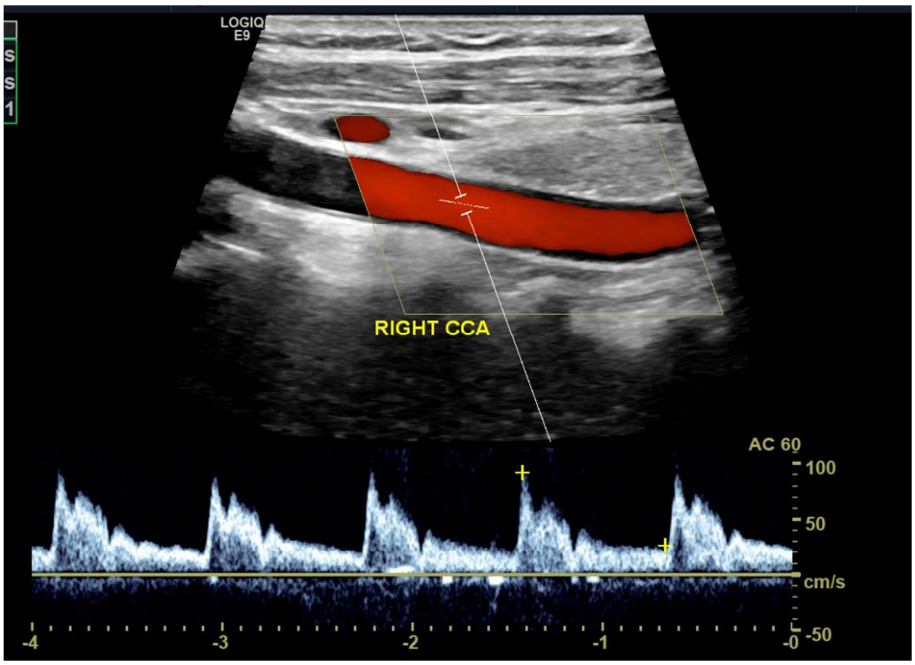


***Figure 4.*** *Blood flow spectrum of internal carotid artery stenosis segment after implementation (with marked images, clean spectrum, sharp boundaries, and no obvious clutter).*

## 3. Result

Before implementing the PDSA cycle from January 2021 to December 2021, the ultrasound image and text report score was (87.46 ± 5.82), and the clinical satisfaction score was (84.46 ± 6.42). Out of 600 carotid artery ultrasound text reports, 348 were in Class A (58%), 168 were in Class B (28%), and 84 were in Class C (14%). The proportion of no or incomplete signs was 24%, the proportion of unmeasured stenosis distal flow rate was 23%, and the proportion of diastole blood flow not displayed was 22%.

After the implementation of PDSA cycle from January 2022 to December 2022, the ultrasound image and text report score was (92.74 ± 3.55) points, and the clinical satisfaction score was (93.14 ± 3.86) points, both of which were higher than before implementation, and the differences were statistically significant (all $P<0.05$). Out of 600 graphic and textual reports, 492 were in Class A (82%) and 108 were in Class B (18%), with no Class C. Young ultrasound physicians have made significant progress in examination standards, with good standardization of images during examinations, significantly improved image quality, more complete textual descriptions, and higher clinical satisfaction. After implementation, the flow velocity measurement of stenosis and distal end reached 92%, but the image was too small in 22%, incomplete in 20%, and diastole blood flow was not displayed in 18%. If the number of Class A graphic and textual reports does not reach the target of over 95%, it will enter the next phase of the PDSA cycle.

## 4. Discussion

The National Ultrasound Quality Control Center pointed out in the "Expert Consensus on Quality Management and Control Indicators for Ultrasound Medicine (2018 Edition)" that 7 quality control indicators are established in three aspects: structure, process, and results, and sub professional groups are established to continuously improve the quality and service level of various ultrasound specialties, which can avoid unnecessary adverse events and even medical disputes. In the past, quality management tools were mostly used in nursing management [4], hospital administrative management, and grade review work [5]. As an independent discipline, ultrasound medicine has become a key focus in ensuring medical safety by actively accepting quality management tools and applying them to ultrasound work, improving ultrasound diagnosis and treatment levels, and better serving clinical needs.

Our hospital is a stroke prevention and treatment center in the local area. In the early stage of construction, there were few clinical applications of ultrasound screening for stroke, and the departments had insufficient understanding of the standardization of vascular ultrasound examination. Stroke is a common cerebrovascular disease caused by insufficient blood supply to intracranial arteries due to cervical vascular lesions, with over 80% of patients suffering from ischemic stroke. Atherosclerotic plaque in the carotid artery will lead to narrowing of the lumen, and the speed and resistance of the distal part of the artery will be reduced after stenosis, leading to the decrease of the blood volume of the intracranial artery, plaque shedding or the formation of thrombus into the cerebral artery embolism, leading to ischemic stroke. Ultrasound measures the diameter of the carotid artery lumen, intima-media thickness, and hemodynamic parameters to comprehensively evaluate the patient's vasoconstriction and accurately determine the location and degree of stenosis caused by plaques. This provides a reference basis for

screening high-risk stroke patients and accurate preoperative evaluation. In order to effectively improve the ability of carotid artery ultrasound screening for high-risk groups of stroke and timely identify the problems in clinical diagnosis and treatment, our department has been implementing quality control for carotid artery ultrasound using the PDSA cycle since 2022. The quality control team has developed various systems, personnel training, inspection process optimization, follow-up feedback, analysis and rectification measures to improve the professional ability of department personnel. Continuously improve the quality of ultrasound images and report text descriptions.

The PDSA cycle combines management tools with medical statistics and is one of the commonly used quality management tools in hospitals. By analyzing factors that affect medical quality, an optimized management method is developed. Include causal analysis charts, flow charts, Plato charts, scatter charts, run charts, and other chart tools. Multiple hospitals in Sichuan Province, Hubei Province, Henan Province, Fujian Province, Anhui Province, and other provinces have analyzed and summarized the reasons for the differences between hospitals, internal personnel, equipment, standards, and doctor-patient relationships, and conducted quality control on the existing problems [6-10]. *Xie Xiaohong et al.* [11] established, trained, and assessed the standards for the practice requirements, consulting room environment, ultrasound instruments, core systems, and operational norms of ultrasound departments in 34 county-level hospitals in Zhejiang Province, resulting in the improvement of prominent problems in ultrasound work year by year and greatly improving the diagnostic level of grassroots ultrasound physicians. *Qian Shasha et al.* [12] effectively improved the clinical diagnosis and treatment level by using self-designed and developed quality management toolkits, forming a good atmosphere for continuous improvement of quality management within the hospital, and continuously enhancing the quality management concept of the entire hospital staff. *Jiang Yuxin et al.* [13] proposed methods such as MFI (improved model), PDSA cycle, lean (lean), DMAIC (six sigma), as well as multidisciplinary collaboration (MDT), visualized quality panels, 5G technology, AI, etc. to help improve the professional level of ultrasound medicine, patient satisfaction, and continuous improvement of ultrasound diagnosis and treatment quality. Wang Hongyan et al. [14] pointed out that the quality control work of ultrasound medicine in China should be continuously promoted through five systems: organization, diagnosis and treatment standards, quality control indicators, quality control standards, and monitoring and early warning evaluation, as well as a standardized ultrasound quality management system to ensure medical quality and safety.

After implementing the PDSA circulation activity in our department, continuous improvement and follow-up feedback have effectively improved the image and text reports of carotid ultrasound examination and clinical satisfaction scores. Young ultrasound physicians have made significant progress in terms of examination standards. After training in the department, it has a significant effect in evaluating the carotid stenosis rate and adjusting the low speed blood flow parameters in diastole. The determination of carotid artery stenosis rate before implementation only relies on the ratio of diameter stenosis rate or area stenosis rate, without referring to the blood flow velocity indicators of the stenosis segment and distal end, leading to clinical belief that the measurement accuracy of stenosis rate is poor; After implementation, the measurement of stenosis segment and distal flow velocity reached 92%. When there are doubts about hemodynamics, a comprehensive diagnosis was made by combining diameter stenosis rate and area stenosis rate, and the report was clinically recognized. Although the implementation of the PDSA cycle has improved the carotid ultrasound image and text report and clinical satisfaction score, it has not yet achieved the predetermined goals. The possible reasons for the analysis are: (1) Some machines in the department are old and have poor image quality; (2) For elderly patients with factors such as obesity, short and thick neck, and poor fit, ultrasound physicians should indicate the presence of clinical non-standard images in their written descriptions; (3) In situations where blood flow velocity is high or low, inexperienced ultrasound physicians do not pay attention to adjusting blood flow parameters and sampling volume to save examination time, which is actually a manifestation of unfamiliarity with instrument adjustment; (4) Conventional ultrasound is not objective enough to determine the nature of plaques, and the concept of low echogenicity as "soft plaques" in ultrasound needs to be updated. The internal characteristics of plaques should be described and whether there is thrombosis should be determined. Accurate indications are the key to clinical control of thrombosis and prevention of stroke.

# 5. Conclusion

In summary, the PDSA cycle effectively improves the graphic report and clinical satisfaction score of carotid artery ultrasound screening, and can be applied to quality control of other single diseases in the ultrasound department, in order to continuously improve the medical quality of the ultrasound department. In the next stage, our continuous improvement direction will explore the use of structured reports, ensure the quality of the reports while speeding up the reporting time, and strive to make the reports comprehensive and legibility [15]; Conducting contrast-enhanced ultrasound to further evaluate plaque stability, explore the relationship between the degree of carotid artery stenosis and stroke, and provide important basis for the prevention and treatment of carotid artery stenosis and stroke high-risk populations, follow-up dynamic observation and treatment, and surgery.

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