

# A Review of Vascular Health Research

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**Abstract:** The development of science has a purpose. From a medical point of view, these developments are all about promoting the healthy development of people and allowing people to live a disease-free life. In order to detect these diseases, scientists use different scientific means to detect the patient's physical condition, so as to use the right treatment. Blood vessels are a vital part of the human body. By using the medical technology MRI, CTA and CEUS, we are able to test the human body. These methods have their own characteristics so in different situation, their function and final result can be different. By combining them together properly, their own functions can be enhanced dramatically and their disadvantages can be minimized.

**Keywords:** MRI, CTA, CEUS, Vascular Health, Medical Examination.

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## 1. Introduction

As organs within the human body and channels for blood transportation, blood vessels play a crucial role in metabolism and blood circulation. As science has continued to elevate, the problem of vascular health has found itself in the spotlight with increasing frequency. According to the information given by the NCCD (national center for cardiovascular disease), we can find out that The prevalence of CVD in China continues to rise and the rate of increase is 48.06% in 2020 compared to 2015. What's more, another data shows that CVD is one of the most important causes of human death. That's because in 2020, the rural and urban CVD accounted for 48.00 and 45.86 percent of deaths, respectively. The previous research have succeed in researching different methods such as CT, MRI and CEUS to conduct vascular health examination. Each inspection method has been explained in detail, but few articles have classified all of these methods according to their application principles, symptoms, advantages, and disadvantages. The present work provides preliminary result for the discussion of characteristics of CTA, MRI and CEUS; their own advantages and disadvantages; their joint application and the prospect of vascular health examination.

## 2. Overview of Blood Tests

Although the exact principle of blood vessels examination methods can be different from each other, their goal is the same: Find out the condition of the blood vessel in human body. The exact condition of the human blood vessel can be determined by these 5 signals: The shape of the vessel, rate of the blood flow, Degree of contraction and diastole, Thrombus or not and Plaque or calcification in the blood vessels.

The shape of the vessel provides heaps of information. It can tell us whether there is disease inside the blood vessels. The normal shape of the vessel is regular round or tubular. If it shows some specific shapes such as twists or spots, then there can be some disease inside the vessel, and spots can be the signal of the disease called as atherosclerosis.

The rate of the blood has really close relationship with the degree of contraction and diastole. The contraction of the vessel can give rise to the slow blood rate or even cause the

blood flow to stop completely, while the rapid blood flow has different result. If the blood flow is rapid, the pressure on the blood vessel wall will increase greatly, which may lead to the rupture of the blood vessel wall and cause early treatment such as cerebral hemorrhage. In conclusion, the rate of the blood can be utilized as an indirect signal of the blood vessel condition.

Thrombus or not and Plaque or calcification in the blood vessels can be seen as really crucial signal in the human body because these these symptoms are more serious manifestations of the condition. For example, according to the current medical research, symptoms such as appearances of new blood vessels in plaque is the main factor that leads to plaque instability, even shedding and formation of thrombus. So it is important to determine the condition of the blood vessel according to these signs.

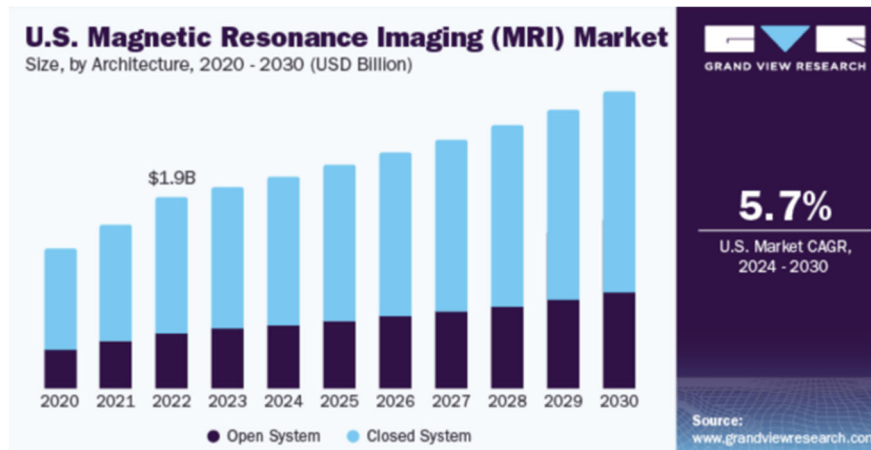
Nowadays, by virtue of the advanced technology, all of these signals can be detected according to different scientific principles. However, there is still no machine which can detect all of these signals at once, which means several methods are required to detect different aspects of the blood vessel. Among them, three technologies: MRI, CTA and CEUS are the most popular methods. In this essay, these three methods will be discussed according to their application principles, symptoms, advantages, and disadvantages.

## 3. Research in Comparing the Difference Between Three Different Vessels Examination Methods.

### 3.1. The utilization of MRI in vascular health examination.

The MRI technology is a non-invasive examining technology which can be used to create detailed 3-D images. This technology is frequently utilized in disease detection, treatment monitoring and diagnosing. Since it doesn't need harmful radiation to detect intrinsic tissue or blood vessel. According to the data given by GVR, the market of the MRI keeps increasing from 2020 to 2024, and the prediction maintains that the market of MRI will keep increasing, which means the MRI is more and more widely utilized.

**Table 1.** The bar chart of the MRI market in USA

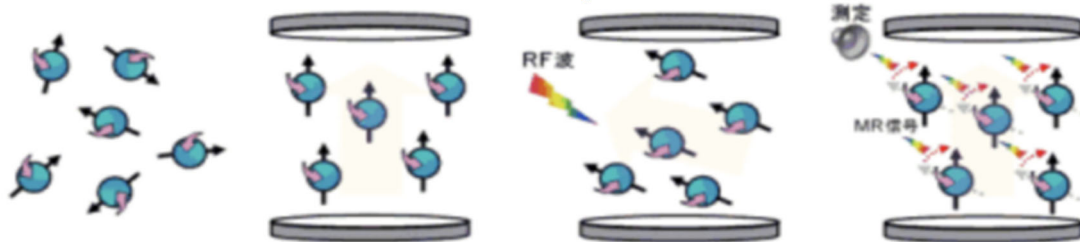


Resource: “Magnetic Resonance Imaging Market Share Report, 2030” [www.grandviewresearch.com/industry-analysis/magnetic-resonance-imaging-market](http://www.grandviewresearch.com/industry-analysis/magnetic-resonance-imaging-market). Accessed 21 July 2024.

So, how does it works? It mainly relies on the magnetic and the water in the human body. As we know, The human body is about 70 percent water, so there are heaps of hydrogen atoms in the human body, and all hydrogen ions carry hydrogen nuclei that present a slightly positive charge. When MRI starts working, it will create a extremely strong magnetic

field, the current will be pulsed through the human body, and the proton, element H in the human body, will be affected and spin until its direction is as same as the magnetic field created by the MRI machine. However, not every proton spins the same angle. Their condition can be different depending on their environment, and according to the difference between the protons, the sensors will detect the condition of these proton and distinguish different tissue or liquid in the human body and produce an elaborate picture according to these information.

**Table 2.** The Principle of the MRI



MRI has heaps of unique characteristic. Main advantages can be these three: First, it doesn't create any harmful radiation since it is magnetic based rather than radical technology based, so even pregnant women or children can have MRI examinations safely. Second, it is precise. It is really sensitive so that it is easy for the MRI machine to detect small tissue in the human body. The property “non-radical technology” also contribute to its precise image. Third, it can avoid the influence caused by the existence of the bone. This is really convenient since if there is the situation such as the bone covered the damaged tissue, the MRI will ignore the bone and exam the tissue correctly. It can be really helpful in some situation such as when the tissue is mixed with the bone fragments.

These characteristics have gave rise to the wide applications. For example, the MRI technology utilization can be a really crucial and useful way to analyze the assessment of carotid artery stenosis in patient with the acute cerebral infarction. [5]What's more, MRI is also effective in examination of atherosclerosis stenosis. [4]

The MRI, however, also has its own disadvantages. Although MRI is not radio active, which means it won't send out the harmful radiation similarly found in X ray or CT, it does use an intense magnetic field, which can cause some dangerous accidents. That's because the magnetic field

extends beyond the machine and attract objects made of iron, such as some steels, and other magnetizable objects which are widely utilized in our daily life; it is even strong enough to attract a wheelchair which is made of iron come across between rooms or make the iron material implants be out of the human body. That's the reason why patients who have implants can not exam their vessel by using the MRI since it can be really dangerous.

### 3.2. The utilization of CTA in vascular health examination.

CTA (Computed Tomography Angiography) is widely utilized in our daily life, and the principles of CTA is similar as the computed tomography (CT), which can be seen as its brother: High-resolution volumetric CT data acquisition, picturing at maximum contrast medium enhancement, and angiographic different dimensional images such as 2-D or 3-D. [10] In the real situation, from CTA to elevated CT examining, the principle of contrast medium enhancement, one basic requirement of the CTA, matters the most. Four key rules of early arterial contrast dynamics can be helpful in understanding the relationship between intravenously injected contrast medium and the resulting time-dependent arterial enhancement. [13] The technical evolution of CT, which shares a lot of similar characteristics with the CTA,

provides heaps of benefits for CT angiography.

Just as what I have mentioned, the utilization of the CTA is based on the contrast agent. Patients need to do some preparation work before the examination, such as fasting for a few hours, to reduce the impact of gastrointestinal contents on the image, and patients may need to take some medications, such as beta blockers, to lower heart rate and reduce exercise artifacts. During CT scanning, contrast agents containing iodine are injected intravenously. This contrast agent will flow through the blood vessels, enhancing their X-ray absorption and making them more clearly visible in CT images. For certain areas of CTA, such as coronary CTA, special injection techniques, such as high-pressure injectors, may be required to ensure that the contrast agent enters the blood vessels quickly and evenly. CT scanners use X-ray beams to scan the human body from multiple angles and obtain a series of tomographic images. During the scanning process, the CT scanner rotates to generate X-rays, while the detector receives X-rays that pass through the human body, generating image data. During the scanning process, the contrast agent which was injected at first will flow into the human blood vessels, and the CT scanner will scan the blood vessels after injected contrast agent reaches them to obtain images of the blood vessels. The scanned data will be transmitted to the computer for processing. Computers use complex algorithms such as Fourier transform to reconstruct the collected raw data into two-dimensional and three-dimensional images. These images can display the morphology, size, and location of blood vessels, as well as whether there are stenosis, occlusion, or other abnormalities. Doctors and technicians can use image processing software to further process images, such as adjusting contrast and brightness, performing multi planar reconstruction (MPR), or generating three-dimensional reconstruction images (3D reconstruction). These treatments help to display the details of blood vessels more clearly, facilitating diagnosis and evaluation.

CTA has heaps of unique advantages: CTA does not require puncture or vascular catheterization techniques, which means the risk is really small and the whole process can be less painful. Apart from possible adverse reactions to contrast agents, there are almost no other complications. What's more, the speed of CTA is really quick since it utilizes spiral CT rapid scanning technology to complete scans in a short period of time, making it suitable for emergency examinations. According to researchers, CTA can effectively evaluate the condition of carotid artery stenosis, detect plaques in a timely manner, and ensure the accuracy of early screening and diagnosis.

However, its disadvantage is also significant. CTA requires injection of contrast agents containing iodine, which may cause allergic reactions or other adverse reactions. Although CTA is a non-invasive examination, it uses X-rays and therefore is exposed to radiation, although the radiation dose is relatively low. So it is inappropriate for pregnant woman or

children. What's more, CTA is not as effective in displaying calcification as MRI, and due to the lack of H protons, CTA images are not sensitive to calcifications. CTA is not suitable for emergency or particularly critical cases, as emergency equipment such as electrocardiogram monitoring cannot enter the CT room. During CTA examination, patients need to remain still, which means patients have to control their body movements. In conclusion, CTA may not be suitable for patients who cannot control their body movements (such as children or those with claustrophobia). The noise generated during CTA scanning may make some patients feel uncomfortable. CTA equipment is expensive and has high maintenance costs, resulting in higher inspection expenses.

### 3.3. The utilization of CEUS in vascular health examination.

The principle of the CEUS is simple. By injecting ultrasound contrast agents containing microbubbles through peripheral veins, these microbubbles are usually composed of sulfur hexafluoride wrapped in phospholipids and can reach various organs and tissues throughout the body through the pulmonary circulation. These injected material can be detected by the sensors and quantitatively measuring the blood flow generated by blood vessels during tumor or inflammatory reactions can help diagnose and evaluate treatment efficacy.

It also has heaps of advantages. First, Compared with imaging techniques such as CT or MRI, CEUS does not emit ionizing radiation and is suitable for patient populations that require multiple follow-up examinations, especially children and chronic disease patients who require repeated examinations. What's more, the composition of ultrasound contrast agent microbubbles is non-toxic and nephrotoxic, suitable for patients with impaired liver and kidney function. Another thing is that CEUS provides high-resolution vascular and tissue imaging, which helps to display lesions more clearly. Finally, compared to CT and MRI, CEUS has relatively lower examination and contrast agent costs, making it an economically effective imaging examination method.

However, its disadvantages are also clear. First, Unlike CT or MRI, CEUS relies more on the operator's skills and experience, which may affect the consistency and accuracy of the examination results. What's more, the contrast agent used in CEUS has a short circulation time in the body and may require multiple injections to observe different sections or lesions. Finally, Performing CEUS examinations requires specialized equipment and personnel training, which may limit its application in certain medical institutions

### 3.4. Mutual cooperation and supplementation

As we know, MRI, CTA and CEUS have their own features and their own disadvantages. If we combine them together, then we can avoid their disadvantages and enhance their abilities of testing.

**Table 3.** Characteristics of different methods

Vascular Health detection methods	Main characteristics
MRI	Soft tissue+nonradiation
CTA	Speed+ vascular display
CEUS	real-time dynamic imaging

And here are possibilities of combination.

**MRI and CTA:** MRI has advantages in soft tissue resolution and non radiation, while CTA performs better in examination speed and vascular display. Both can be used in combination, MRI can provide more detailed soft tissue and vascular information, while CTA can quickly assess vascular stenosis and occlusion.

**MRI and CEUS:** MRI has advantages in providing multi parameter information and radiation free imaging, while CEUS performs better in and high-resolution vascular imaging. CEUS can serve as a supplement to MRI, especially in situations where real-time observation of blood flow dynamics is required.

**CTA and CEUS:** CTA has advantages in rapid diagnosis and vascular imaging, while CEUS performs better in terms of radiation free and high safety. CTA can be used for preliminary assessment of vascular condition, while CEUS can be used for further observation of blood flow dynamics and vascular wall conditions.

#### 4. Summary and Prospect

As the previous research have showed, MRI, CTA and CEUS have their own unique characteristics and it is important to determine the utilization of these technology according to the situation. By selecting and combining MRI, CTA, and CEUS reasonably, the patient's condition can be evaluated more comprehensively, providing more accurate diagnosis and treatment plans, since the combination of different technology can enhance its own ability significantly.

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