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Original Article

Modified retrospective ECG-gating towards surgical method selection for aortic dissection

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Abstract: Background: Stanford A-type aortic dissection is one of the greatest risks of cardiovascular surgical diseases. How to actively and effectively treat this disease and reduce the mortality has been a problem in cardiovascular surgery. Purpose: To investigate the guiding values of modified retrospective ECG-gating (MR ECG-gating) towards the surgical method selection for Stanford A2- and A3-type aortic dissection. Methods: 10 patients with Stanford A2- and A3-type aortic dissection identified by the aortic CT angiography (CTA) were enrolled in this study. MR ECG-gating scanning was performed in 8 patients and the conventional scanning was performed on other 2 patients. The scanning parameters of intelligent collaboration technology (iCT) and performance of CTA were analyzed. Results: The contrast agent filling of arterial lumen of 8 patients who were performed with MR ECG-gating scanning was good, which could not only be accurately qualified, but also be used to accurately determine the positions of true/false double lumen and intimal rupture, as well as the damage situations of aortic valve. The contrast agent filling of arterial lumen of 2 patients who were performed with conventional aortic CTA scanning was poor, which could only exhibit the existence of aortic dissection, while could not accurately determine the positions of true/false double lumen and intimal rupture. Conclusion: MR ECG-gating CTA scanning can clearly exhibit the rupture location and size of Stanford A2- and A3-type aortic dissection, thus having certain guiding value towards the surgical method selection.

Keywords: Aortic dissection, tomography, angiography, modified retrospective ECG-gating

Introduction

Aortic dissection is an acute vascular surgical disease. In this disease, the blood enters the tunica media from the rupture of aortic tunica intima and then expands along the longitudinal axis, so the stripped state of two aortic layers is formed [1]. One statistical study in USA shows that, the hospitalization rate for aortic dissection is about 10/10 million people per year [2]. The common causes for aortic dissection include high blood pressure, atherosclerosis and trauma [3], and the congenital vascular developmental defect and systemic connective tissue autoimmune diseases can also be found [4]. In Stanford typing, the type A dissection is much more complex, which often involves the ascending aorta and branch vessels of aortic arch. Stanford A2- and A3-type will involve the aortic valve [5]. Stanford A-type aortic dissection is one of the greatest risks of cardiovascular surgical diseases. How to actively and effectively treat this disease and reduce the mortality has been a problem in cardiovascular surgery [6]. The preoperative accurate judgment of dissection-involved range and rupture position is the key towards the surgical method selection and successful surgery [7]. This study collected the intelligent collaboration technology (iCT) data of 10 cases of Stanford A2- and A3-type aortic dissection, who were treated with modified retrospective ECG-gating (MR ECG-gating), and investigated the guiding values of MR ECG-gating towards the surgical method selection of Stanford A2- and A3-type aortic dissection.

Subjects and methods

Subjects

From June 2010 to March 2012, 10 patients with Stanford A2- and A3-type aortic dissection who were treated in the Fifth Affiliated Hospital of Zhengzhou University (Zhengzhou, China)

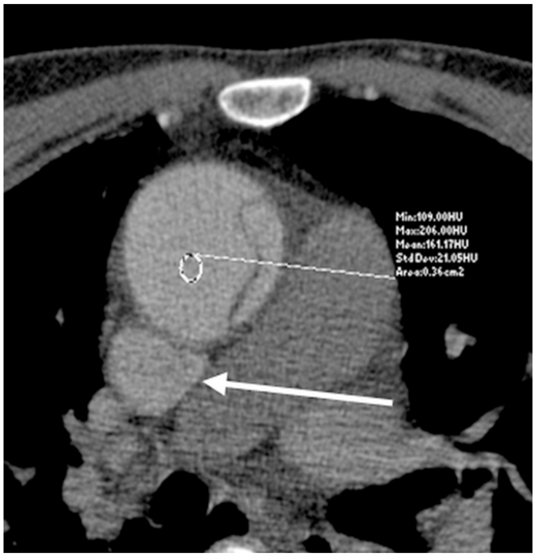

Figure 1. The conventional scanning exhibited that the contrast agent filling of aortic lumen of Stanford A2- and A3-type aortic dissection was poor (white arrow).

were enrolled in this study. There were 7 males and 3 females, aged 32-63 years (52.6±10.71 years). 7 patients had the history of hypertension, 2 patients had obvious history of trauma combined with fracture, and 1 patient was asymptomatic while finding aortic dissection during health examination. The patients had typical clinical symptoms including sudden severe chest pain and chest tightness along the aorta direction. The patients were clinically suspected with aortic dissection, aortic rupture or coronary heart disease before aortic CT angiography (CTA).

Examination methods

iCT was applied to examine the patients. The bilateral infraclavicular fossa and bilateral lateral abdominal walls were connected with the ECG lead. The patient was in the supine position, and the in-bedding was started from the foot. The scanning range was from the thoracic inlet to the pelvic outlet. The scanning direction was set as the out-bedding scanning. The patient held the breath before scanning. The scanning parameters were as follows: 100-120 KV, 200-400 mA, slice thickness 0.9 mm, scanning interval 0.45 mm, pitch 0.20. 8 patients were performed with MR ECG-gating technology. The non-ionic contrast agent (iopromide 370 injection) was bolus-injected through the median cubital vein. The conventional dosage was 80 ml, with the bolus injection rate as 4.0 ml/s, and 40 ml saline was also bolus-injected with the same flow rate. The intermittent tracing automatic triggering technology was used. The region of interest (ROI) in the descending aorta diaphragmatic layer was also set. When the intracavity threshold of descending aorta reached 100 HU, the scanning was automatically triggered with 20 s delay. Other 2 patients were performed with conventional scanning which did not use the ECG-gating technology. The scanning was started conventionally 12 s after automatic triggering. The bolus injection rate of contrast agent was 4.0-5.0 ml/s. The data obtained by the two scanning methods were all performed with the conventional recombination of 45% and 75% phase of RR interval, with thickness of reconstructed slice as 0.9 mm and interval as 0.45 mm.

Image reconstruction and analysis

All data were transmitted into Extended Briliance Workspace workstation (Philips Corp., Amsterdam, Holland) for analysis and processing of volume rendering (VR), curve-plane recombination (CPR), multiplanar reconstruction (MPR). MPR, CPR and VR could stereoscopically display the origin of aortic branches and their relationships with the dissection [8]. The reconstructed images were combined with the axial images of aortic CTA raw scanning data for the focused observation of location and size of dissection rupture, involved important branch arteries (coronary artery, partial head and neck arteries, superior mesenteric artery, celiac trunk, bilateral renal arteries, etc), relationship between the true and false lumen, involvement of aortic valve, and conditions of inflow and outflow tract of dissection pseudocoele. The involvement degree of aortic valve and the changes of left ventricular functions were analyzed. Meanwhile, the diameters of aortic root, brachiocephalic proximal aorta and left subclavian artery, as well as those at the beginning part of brachiocephalic trunk, left common carotid and left subclavian artery, were measured for the early surgery.

Results

Among 10 patients, 2 patients were performed with conventional scanning. They exhibited poorer contrast agent filling of aortic lumen (**Figure 1**). The intra-aortic lumen CT value only

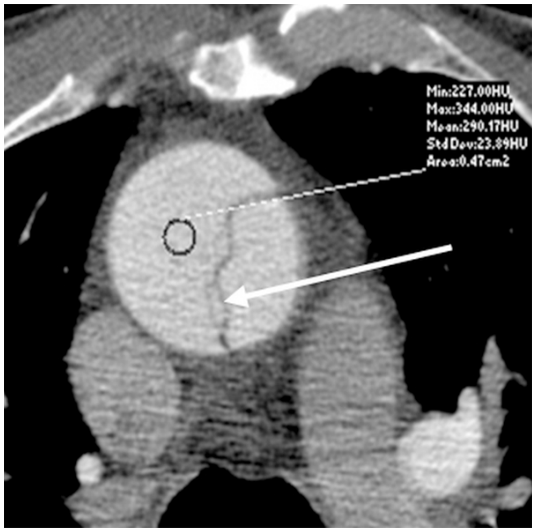

Figure 2. MR ECG-gating scanning significantly increased the contrast agent concentration within the aortic lumen (white arrow).

Figure 3. VR image clearly showed the tearing location of aortic dissection tunica intima (white arrow).

reached 160 HU, which could only be used to determine the existence of dissection, but not to perform the accurate locating and qualitative diagnosis. The rest 8 patients were performed with MR ECG-gating scanning, which revealed that the contrast agent filling of aortic lumen was significantly improved (**Figure 2**). The CT value reached 290 HU. VR (**Figure 3**), CPR (**Figure 4**) and MPR (**Figure 5**) were combined with the aortic CTA raw scanning data for analysis and processing of axial images, and the lesions were clearly diagnosed as Stanford

Figure 4. CRP clearly showed the tearing location and size of tunica intima (white arrow).

A2- and A3-type thoracic aortic dissection. In these 8 cases, the maximal and minimal rupture diameters of aortic dissection were 7.8 and 3.6 mm, respectively, and the dissection in 3 cases extended to the root of aortic arch, involving the head and neck vascular branches (**Figure 6**). In other 5 cases, the distal segments of descending aorta were involved, and the celiac trunk, superior mesenteric artery and renal artery were involved in various degrees. The aortic valves of these 8 cases all had various degrees of tearing. The 75% phase displayed the aortic insufficiency, thus the contrast agent regurgitation existed. The cardiac function test revealed that, the left ventricular functions in these 8 cases were not significantly decreased, and the ejection fraction was not significantly decreased.

Discussion

The common typing methods towards aortic dissection are the DeBakey typing and the Stanford typing. The DeBakey typing is divided into three types. Type I is the most common, accounting for 60% to 70%. The rupture is in the ascending aorta, and crosses the aortic arch and extends distally to the descending aorta and beyond. In type II, the rupture starts and is limited in the aortic aorta. In type III, the rupture starts at the descending aorta. The lesions extend distally, and retrogradely extend

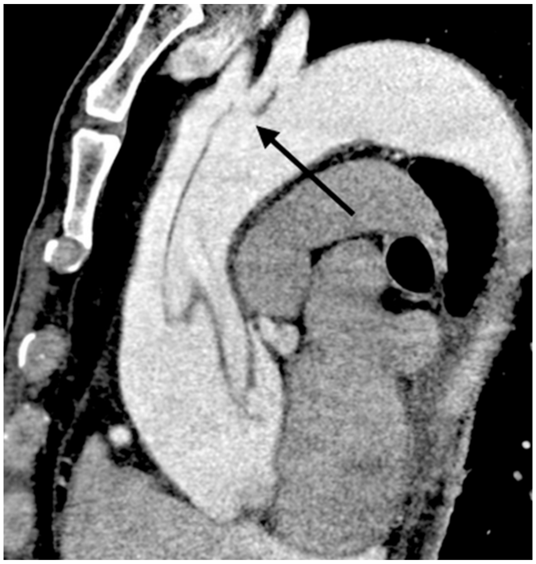

Figure 5. MPR clearly showed the involvements of partial head and neck vascular branches (black arrow).

Figure 6. The original axial image showed the neck involved vessels (white arrow).

to the ascending aorta and aortic arch, which is rare in other two types. This type accounts for 20% to 30% [9, 10]. The Stanford typing is divided into A and B type. In type A, the dissection involves the ascending aorta, regardless of the distal end ranges. In type B, the dissection involves the descending aorta which lies distally to the opening of left subclavian artery [11, 12]. According to the lesions on the aortic root, the Stanford typing is divided into A1, A2 and A3 type [13]. Type A1 exhibits the normal aortic sinus. The sinus-tube joint and its proximal segment are normal, or only have one avulsion of aortic valve joint, while without significant aortic insufficiency. Type A2 exhibits the mild aortic sinus involvement. The diameter of aortic sinus is less than 3.5 cm. The dissection involves the right coronary artery, resulting in the partial or complete avulsion of tunica intima at its opening site. The avulsion of one or two aortic valve joints causes the mild to moderate aortic insufficiency. Type A3 exhibits the severe involvement of aortic sinus. The sinus diameter is 3.5-5.0 cm or greater than 5.0 cm. The intimal structure at the sinus-tube joint shows avulsion and damage, accompanied by the severe aortic insufficiency. Presently, the surgical approach is still the most effective method in treating the Stanford type A dissection (DeBakey type I, II) [14]. However, the difficulty of surgical procedure is big. There are plenty of complications, and the perioperative mortality rate is high, especially the Stanford A2- and A3-type.

There are many examination methods including ultrasound, DSA and MRA towards the aortic dissection, and most of them can achieve the determination of location and size [15]. The ultrasound examination can provide certain significance for the aortic CTA scanning [16], but the ultrasound lacks the characteristic of direct and holistic viewing. DSA is an invasive examination method, and may cause the secondary damages towards the already torn aortic intimal sheets. MRA cannot be used towards the patients with a pacemaker or metallic foreign bodies [17], while the multi-slice computer tomography scanning has the advantages of fast speed, large-scale data acquisition and multi-faceted reconstruction, thus it makes the aortic dissection examination much more convenient and efficient [18]. As Stanford A2- and A3-type aortic dissection will involve the aortic valve, the programs of CTA examination cannot be the same as other types of aortic dissection. Due to valvular dysfunction, the left ventricular valve will exhibit the insufficiency in the diastolic stage because of tearing. The contrast agent inside the aortic cavity will regurgitate back into the left ventricle, thus the pressure inside the aortic lumen is reduced, and the fluid flow is slowed down. So the aortic cavity cannot be filled by enough contrast agent, leading to insufficient contrast agent inside aortic lumen when the conventional scanning program is started. Therefore, the examination reliability is reduced, and the examination fails [19]. The modified scanning is performed as follows: when detecting the effective concentration of contrast agent inside ROI of diaphragmatic muscle level of descending aorta, the scanning starting time is artificially delayed, so the aortic lumen can obtain sufficient filling of contrast agent, and the desired examination results can be achieved. Therefore, before the aortic CTA examination, the ultrasound can be used to initially determine whether the aortic dissection involvs the aortic valve. This can provide some guidance for the selection of aorta CTA scanning program. In this study, 8 patients are performed with MR ECG-gating scanning and have obtained clear and qualitative diagnosis. While other 2 patients who are performed with the conventional aortic CTA scanning exhibit the poor contrast agent filling. Although the aortic dissection can be shown, the true/false double lumen and intimal rupture cannot be accurately determined.

There are plenty of surgical programs towards the aortic dissection according to dissection-involving ranges, including traditional Bentall or David surgery, half and full arch replacement, aortic isolation surgery and hybrid surgery developed in recent years [20]. However, as the surgery is complex, the operation procedure is difficult, so the preoperative qualitative and localization diagnosis need to be done clearly. The Stanford A2- and A3-type aortic dissection often involve the aortic valve, so the aortic valve repair or valve replacement is often required. Stanford A1-type aortic dissection generally will not involve the aortic valve, and the valvular functional change needs not to be considered, so specifying the aortic valvular involvement has more value towards the surgical approach selection than the other examination methods [21].

The conventional scanning technology does not use the ECG-gating. The obtained data will exhibit the overlapped images around the aorta after the reconstruction. Although it can definitively diagnose the existence of aortic dissection, it does not accurately show the location and size of intimal rupture within the dissection, and the situation of true/false lumen also cannot be displayed. The retrospective ECG-gating uses the multi-phase scanning technique [22], which can not only accurately display the intimal torn rupture and reflux extent after the aortic valve tearing, but also clearly exhibit the situations of true/false lumen and involvement extent of branch arteries.

In conclusion, the iCT-MR ECG-gating scanning has the wide checking vision, and can perform the multi-faceted image reconstruction. It can not only definitely diagnose the location and size of intimal rupture within the aortic dissection, but also clear the involvement degree of aortic valve. Compared with conventional scanning programs, this method has unmatchable guiding values towards diagnosis of Stanford A2- and A3-type aortic dissection, especially for the decision and selection of surgical methods.

Disclosure of conflict of interest

None.

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