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The potential value of intravascular ultrasound imaging in diagnosis of aortic intramural hematoma

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Abstract

Objective To evaluate the potential value of intravascular ultrasound (IVUS) imaging in the diagnosis of aortic intramural hematoma (AIH). **Methods** From September 2002 to May 2005, a consecutive series of 15 patients with suspected aortic dissection (AD) underwent both IVUS imaging and spiral computed tomography (CT). Six patients diagnosed as acute type B AIH by CT or IVUS composed the present study group. **Results** The study group consisted of five males and one female with mean age of 66 years old. All of them had chest or back pain. In one patient, CT omitted a localized AIH and an associated penetrating atherosclerotic ulcer (PAU), which were detected by IVUS. In another patient, CT mistaken a partly thrombosed false lumen as an AIH, whereas IVUS detected a subtle intimal tear and slow moving blood in the false lumen. In the four rest patients, both CT and IVUS made the diagnosis of AIH, however, IVUS detected three PAUs in three of them, only one of them was also detected by CT, and two of them escaped initial CT and were confirmed by follow up CT or magnetic resonance imaging. **Conclusions** IVUS imaging is a safe examination and has high accuracy in the diagnosis of AIH, particularly for diagnosing localized AIH, distinguishing AIH with thrombosed classic AD and detecting accompanied small PAUs.

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1 Introduction

Aortic intramural hematoma (AIH), first described in 1920 by Krukenberg,[1] belongs to “acute aortic syndrome (AAS)” followed by penetrating atherosclerotic ulcer (PAU) and the classic acute aortic dissection. It occurs as a bleeding into the aortic wall (media) without initial rupture of the intima, the classic flap formation and direct flow communicating between the true and the false lumen. With advent of non-invasive imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI) and transesophageous echography (TEE), AIH has been frequently recognized. Although these non-invasive modalities have been reported to have accuracy in diagnosis of AIH,[2–5] they also have some limitations.[3,6–8]

Only a few studies have evaluated the value of intravascular ultrasound (IVUS) imaging in patients with AAS, moreover, most of them used a 20-MHz IVUS probe that has limitations in a dilated aorta.[6,9–12] Recently, a 9 MHz IVUS probe is commercially available; however, the experiences about it are very scant.

2 Methods

2.1 Patients

This was a single centre, prospective and observational study. We included patients with suspected aortic dissection (AD) after obtaining an informed content and excluded patients who need an urgent intervention. All patients underwent both IVUS imaging and spiral CT. CT was performed within 24 hours from onset of symptom, and the interval time between CT and IVUS imaging was less than one week. In the present study, we will focus on the patients who were diagnosed as AIH by CT or IVUS.

2.2 IVUS imaging

A 9F 9-MHz mechanic IVUS probe (Ultra ICE™

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intracardiac echo catheter, Boston Scientific) was introduced to aortic root with the help of a 0.035-inch guide wire and a 110-cm long sheath under fluoroscopy via right femoral artery. After obtaining an optimal cross-sectional aortic image, it was manually pulled back and IVUS images were simultaneously recorded on the videotape for subsequent analysis.

2.3 IVUS imaging analysis

Two cardiologists (Hu W & Schiele F) who were blinded to the results of other imaging techniques performed IVUS imaging analysis. We adopted Alfonso's definition for AIH by IVUS and made some modifications. AIH was defined as a crescentic, focal or diffuse thickening aortic wall with layered structures separated by echolucent spaces. PAU was defined as a crescentic, localized and outpouching thickening aortic wall with heterogenerous echoic density that communicated with the lumen via an uncontinuous intimal. The circumferential and longitudinal extent of an AIH, as well as its relationship with aortic side branches and peri-aortic effusion were also recorded.

2.4 Spiral CT

We performed spiral CT (Simens, 4 multibarret, with and without injection of contrast media) by standard methods. Radiologists interpreted CT by adopting standard definitions. Briefly, without contrast, an AIH is defined as crescentic or circular, focal or diffuse thickening aortic wall with a higher density than blood, and with contrast, it has the same features, but with a lower density than blood. PAU is defined as a narrow neck, outpouching, contrast filled ulceration.[2,4,5]

3 Results

3.1 Patient demographics (Table 1)

From September 2002 to May 2005, a consecutive series of 15 patients underwent both IVUS imaging and spiral CT. Six of them diagnosed as acute type B AIH by these two modalities composed the current study, which included five males and one female with mean age of 66 years old. All of them had symptom and had CT and IVUS. Four of them were also performed TEE or MRI or aortography.

3.2 IVUS and CT findings (Table 2)

There were no complications related to IVUS imaging in all the patients and the mean procedure time was 15 minutes. Even in a very dilated aorta, IVUS could provide a good cross-sectional aortic image of entire aorta and most of the side branches. The largest aortic diameter was 89 mm. The detecting rate of three arch branches, celiac trunk artery, superior and inferior mesenteric arteries, and renal arteries were 100%.

In case 1, CT omitted a localized AIH and an associated PAU, which were detected by IVUS (Figure 1). In case 2, CT mistaken a partly thrombosed false lumen as an AIH, while IVUS detected a subtle intimal tear and slow moving blood in the false lumen (Figure 2). In case 3, 4, 5 and 6, both CT and IVUS made the diagnosis of type B AIH. However, IVUS detected three accompanied PAUs, only one of them was also detected by CT (Figure 5), two others were overlooked by CT and confirmed by follow up CT or MRI (Figure 3 and 4).

3.3 Treatment and follow up

All patients received medical therapy except case 1, who was treated surgically because of aneurismal dilatation of the false lumen. All of them were followed by clinic visits or telephone interviews and received regular

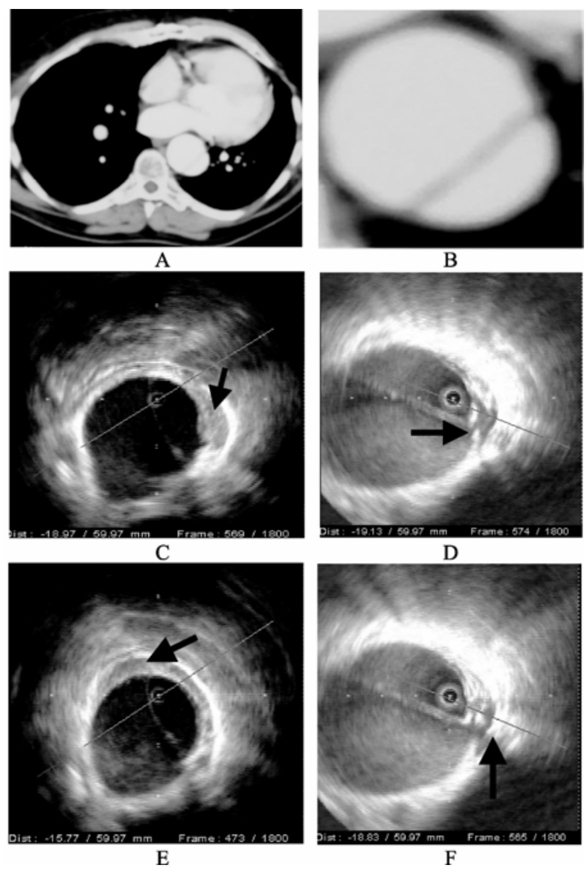

Figure 1. CT and IVUS imaging of case 1. There was no evidence of AIH or PAU in image A and B (CT with contrast, 2002/10/18), but a localized AIH was found by IVUS as shown in image C and E (indicated by a black arrow, IVUS, 2002/10/23). This AIH was accompanied by a small PAU (indicated by a black arrow in image D and F, redo IVUS imaging after adjusting zoom, 2002/10/23). CT: computed tomography; IVUS: intravascular ultrasound; AIH: aortic intramural hematoma; PAU: penetrating atherosclerotic ulcer.

CT examinations. The mean follow up time was 17.7 ± 12.2 months (Ranged from 4 months to 33 months). No deaths occurred. In case 3, 4 and 5, the AIH developed into aneurysm at site of the PAU. The AIH almost resolved completely in case 6. The subtle intimal tear kept unchanged in case 2.

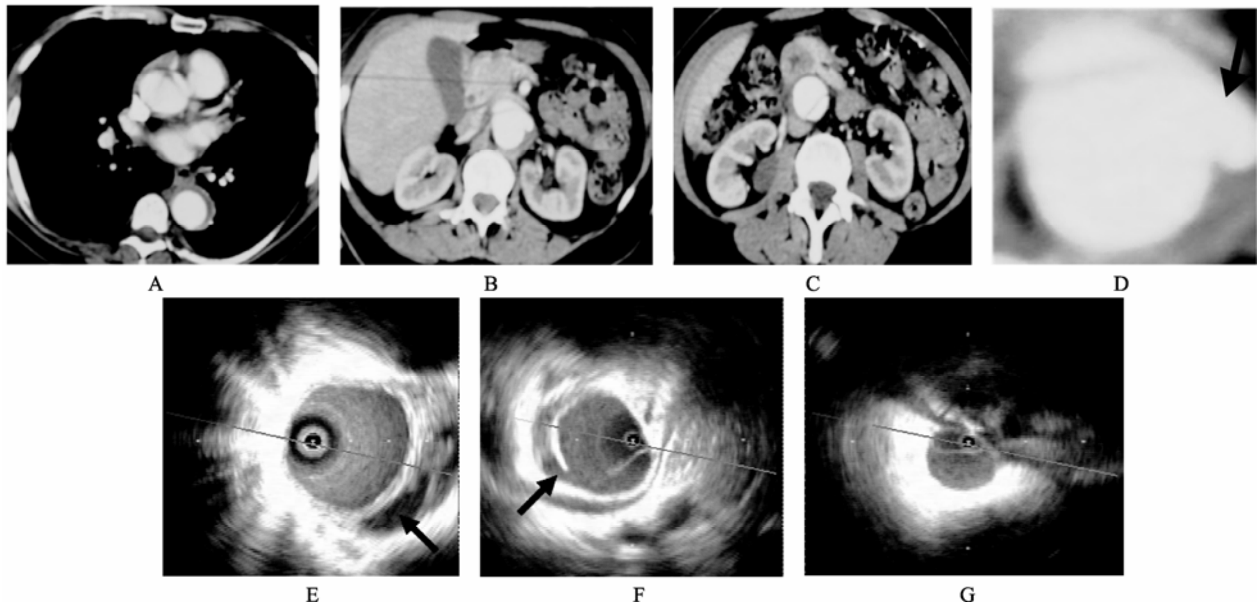

Figure 2. CT and IVUS imaging of case 2. Descending AIH and abdominal CAD were documented in image A-D (CT with contrast, 2005/02/25). Image E-G were correspondent IVUS images (2002/02/25). The black arrow in image E indicated slow moving blood. The black arrow in image F indicated a subtle intimal tear. After carefully reviewing CT images, we found this intimal tear (indicated by a black arrow in image D). CT: computed tomography; IVUS: intravascular ultrasound; CAD: classic aortic dissection.

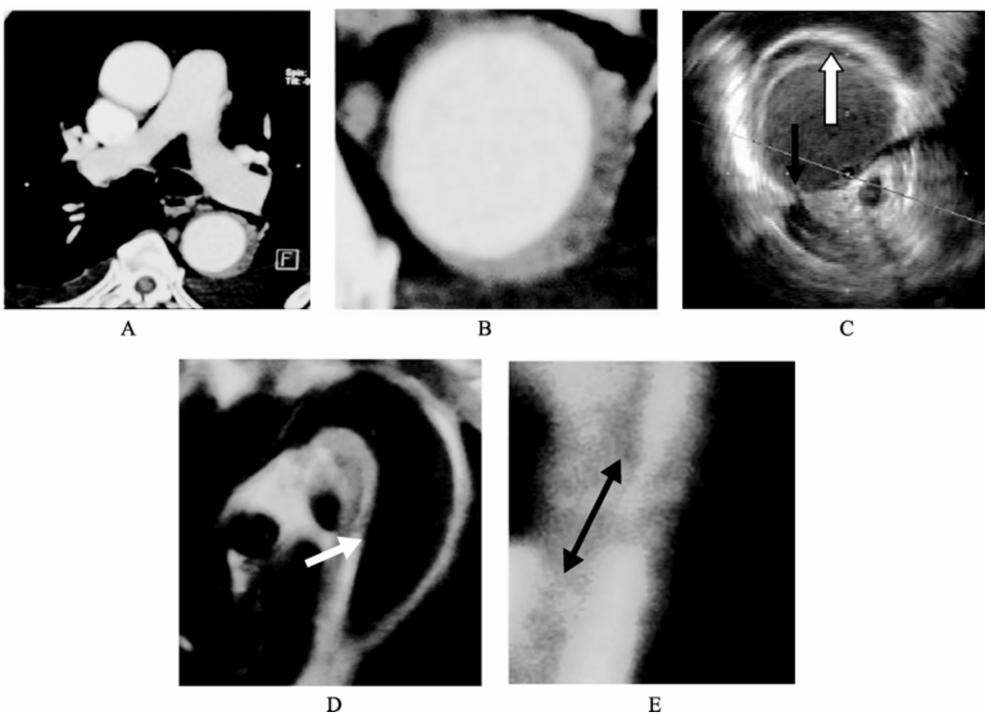

Figure 3. CT and IVUS imaging of case 3. A descending AIH was showed in image A and B, but with no evidences of PAU (CT with contrast, 2002/09/18. Image B was a zoomed copy of image A). Image C was a correspondent IVUS image (2002/09/18). The white arrow indicated AIH and the black arrow indicated a PAU. This PAU was confirmed by MRI (2002/09/25, indicated by a black arrow in image D and E, Image E was a zoomed copy of image D). CT: computed tomography; IVUS: intravascular ultrasound; PAU: penetrating atherosclerotic ulcer; MRI: magnetic resonance imaging.

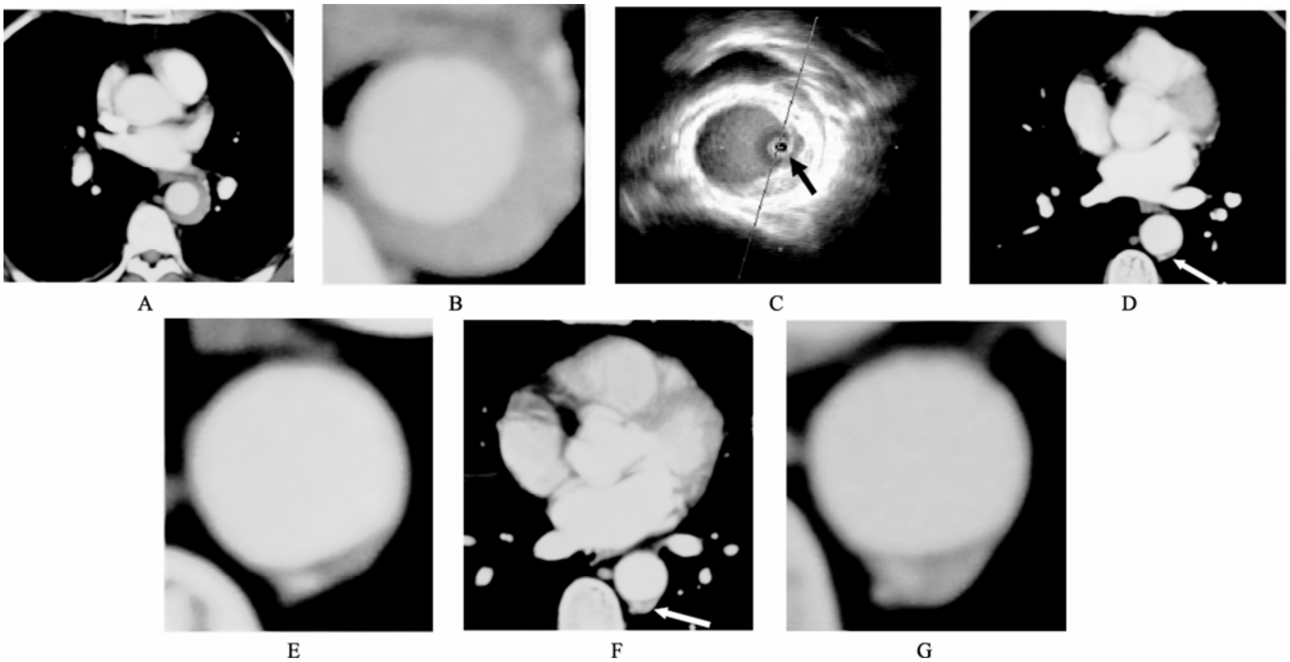

Figure 4. CT and IVUS imaging case 4. AIH was showed in image A and B (CT with contrast, 2004/03/17), there were no evidence of a PAU. A small PAU was detected by IVUS imaging (2004/03/19), which was indicated by a black arrow in image C. The disappearance of AIH and the appearance of a small PAU were showed in image D and E (indicated by a white arrow in image D. CT with contrast, 2004/04/14). The enlargement of the PAU was showed in image F and G (indicated by a white arrow in image F. CT with contrast, 2004/08/03). CT: computed tomography; IVUS: intravascular ultrasound; AIH: aortic intramural hematoma; PAU: penetrating atherosclerotic ulcer.

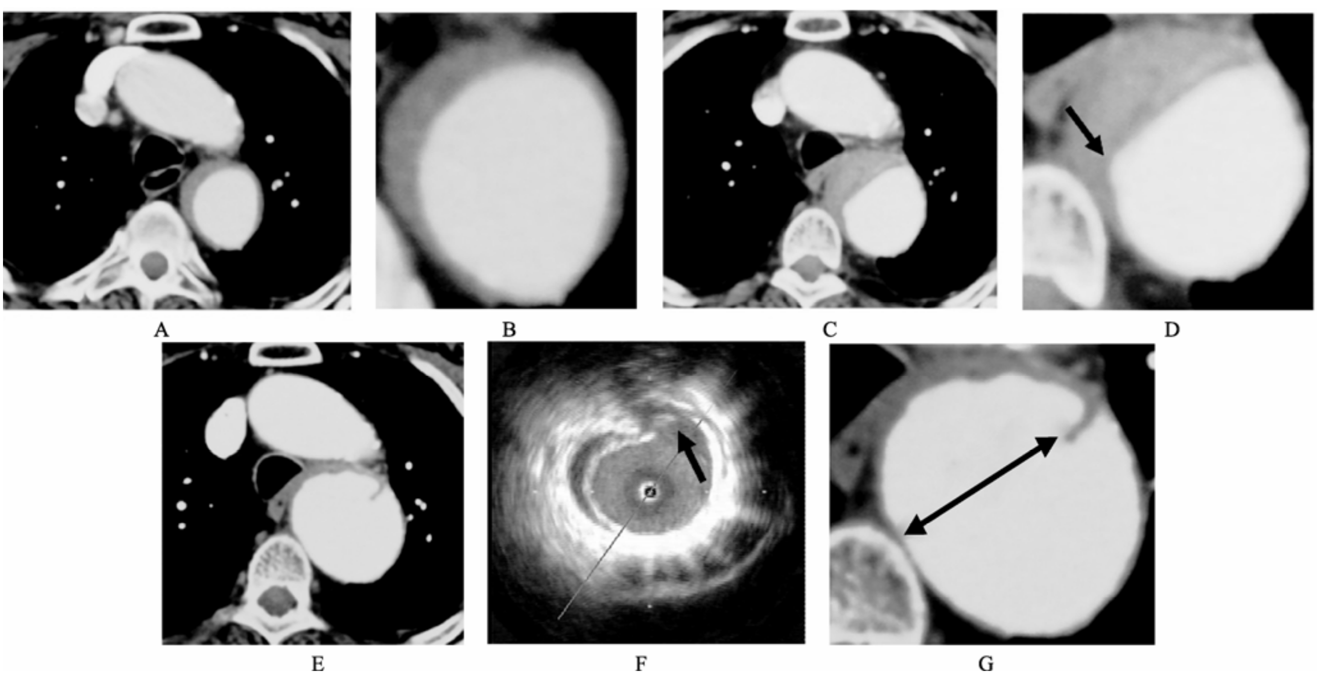

Figure 5. CT and IVUS imaging of case 5. There was no ulcer-like projection in imaging A and B (CT with contrast, 2004/04/17). A new onset of ulcer-like projection suspected as a PAU in image C and D (indicated by a black arrow in image D, CT with contrast, 2004/06/08). This new onset of ulcer-like projection was demonstrated as a PAU by IVUS in image F (indicated by a black arrow in image F, 2004/06/15).This PAU was also confirmed by follow up CT in image E and G (indicated by a double–head arrow in image G, CT with contrast, 2004/08/03). CT: computed tomography; IVUS: intravascular ultrasound; AIH: aortic intramural hematoma; PAU: penetrating atherosclerotic ulcer.

Table 1. Patient demographics.

Case	Gender	Age	HTA	HCT	DM	Smoke	FH	Symptom
1	M	53	+	-	-	-	-	+
2	F	64	-	-	-	-	-	+
3	M	74	+	-	-	+	-	+
4	M	54	+	-	-	+	-	+
5	M	73	-	-	-	+	-	+
6	M	75	+	-	-	-	-	+

M: male; F: female; HTA: hypertension; HCT: hypercholesterolemia; DM: diabetes mellitus; FH: family history; +: Yes; -: No. Symptom represented acute chest or back pain.

Table 2. Comparison between IVUS and CT imaging.

Case	CT	IVUS	Interval time (days)	Confirmations	Treatment	Outcome
1	CAD	CAD+AIH+PAU	5	No	Surgical	Stable
2	CAD+AIH	CAD	0	Reviewing	Medical	Stable
3	AIH	AIH+PAU	0	Follow up MRI	Medical	Aneurysm
4	AIH	AIH+PAU	2	Follow up CT	Medical	Aneurysm
5	AIH+PAU	AIH+PAU	7	No	Medical	Aneurysm
6	AIH	AIH	2	No	Medical	Regressed

IVUS: intravascular ultrasound; CT: computed tomography; CAD: classic aortic dissection; AIH: aortic intramural hematoma; PAU: penetrating atherosclerotic ulcer; MRI: magnetic resonance imaging.

4 Discussion

AIH was first described in 1920 by Krukenberg,[1] and characterized by the absence of intimal tear and direct flow communicating between true and false lumen. Because aortography had been long time as a standard imaging technique in patients with aortic disease, but it is insensitive in the diagnosis of AIH, and AIH was less recognized before. With advent of non-invasive imaging techniques such as CT, TEE and MRI, AIH has been frequently reported. By using these non-invasive modalities, the prevalence of AIH among patients with suspected AAS is ranged from 5% to 20%, correlated well with autopsy studies that ranged from 4% to 13%.[4,13–15] Although these non-invasive modalities have been demonstrated to have high accuracy in diagnosis of AIH, they also have some limitations.[2–8]

In 1990, Weintraub *et al*.[9] first performed IVUS imaging in a patient with acute classic aortic dissection (CAD). After that, several studies have evaluated the value of IVUS imaging in patients with CAD, but up to now, only one study performed IVUS imaging in a series of eight patients with AIH.[6,9–12] Therefore, the role of IVUS imaging is far from established in patients with AIH. Moreover, most of these studies used a 20-MHz IVUS probe, which had limitations in a very dilated aorta. Recently, a 9-MHz IVUS probe is commercially available, which can theoretically overcome this kind of limitation. However, the experiences about it are very scant. To our knowledge, our study is the first one that used this new system in a series of patients with suspected AD. Not surprisingly, our study showed that it could supply us a good cross-sectional aortic image of entire aorta even in a very dilated aorta and most of its side branches.

According to international registration of aortic dissection study, CT is presently the most often used imaging technique, and it often needs two or more imaging techniques to establish the diagnosis of AIH.[4,5] In our study, all six patients underwent spiral CT and four of them were also performed TEE, MRI or aortography, which may reflect the actual clinical practice. It is generally accepted that spiral CT has a similar accuracy as TEE and MRI in diagnosis of AIH. Therefore, IVUS findings were mainly compared with those of spiral CT in our study.

We adopted Alfonso's definition for AIH by IVUS and made some modifications.[6] By using this definition, IVUS imaging made the diagnosis of AIH in five patients, four were confirmed by CT, but one localized AIH was overlooked by CT. In addition, CT made a false diagnosis of AIH in one case, because it overlooked a subtle intimal tear and slow moving blood in the false lumen, which were detected by IVUS. Thus, we believe that IVUS has a high accuracy in diagnosis of AIH. However, we can not draw any definite conclusions on the sensitivity and specificity of IVUS in diagnosis of AIH because of our small sample size and non-randomised characteristics.

In 1995, Alfonso *et al*.[6] reported that two localized AIHs detected by IVUS were overlooked by TEE. In our study, as stated above, one localized AIH detected by IVUS was overlooked by CT. Therefore, we think that

IVUS may be more sensitive than non-invasive imaging techniques to detect a localized AIH.

Although current imaging techniques have high sensitivity and specificity in the diagnosis of CAD, it is still a big problem for them to differentiate an AIH from a CAD with a subtle intimal tear and a fully or partly thrombosed false lumen.[2] One case example in our study showed that IVUS could be helpful in this aspect.

Despite the remaining controversy,[16–19] more and more authors agree that the prognosis of AIH with a PAU is worse than that without a PAU. Recently, Ganaha *et al.*[17] reported the occurrence of 52% PAU in their patients with AIH by using CT, and they demonstrated that AIH with PAU had poorer outcome than AIH without PAU. However, small PAU will escape current used imaging techniques.[18,19] In our study, four of five AIH were found by IVUS to be accompanied by a PAU, one of them was also detected by CT, and two of rest three were confirmed by follow up CT or MRI. So we believe that IVUS is more sensitive than CT to detect a small PAU. The frequency of PAU in patients with AIH reported by us was strikingly higher than that reported by others, which should be interpreted cautiously because we included exclusively type B AIH and used a different modality.

Study limitations: (1) there were no complications in our study, IVUS imaging is an invasive examination that has potential damages; (2) the time interval between IVUS imaging and CT was short and there was no evidence of clinic progression. Thus, we could not exclude possible changes during that period of time. And (3) not all PAUs had confirmations, so we can not exclude the false positive one.

In one words, IVUS imaging is a safe examination and has high accuracy in the diagnosis of AIH, particularly for diagnosing localized AIH, distinguishing AIH with thrombosed classic AD and detecting accompanied small PAUs.

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