World Journal of Cardiovascular Diseases, 2021, 11, 58-68
https://www.scirp.org/journal/wjcd
ISSN Online: 2164-5337
ISSN Print: 2164-5329

The Evaluation Characteristics of Type B Aortic Intramural Hematoma and Ten Years Treatment Outcomes

Jinguo Zhu[1,2,3*], Hongbo Hu[3]

[1]Department of Cardiothoracic Surgery, The Second Affiliated Hospital of Shantou University Medical College, Shantou, China
[2]Department of Cardiothoracic Surgery, The People's Hospital of Sanya, Sanya, China
[3]Department of Cardiothoracic Surgery, Liuzhou Municipal Liutie Central Hospital, Liuzhou, China
Email: *zsjg2009@163.com

How to cite this paper: Zhu, J.G. and Hu, H.B. (2021) The Evaluation Characteristics of Type B Aortic Intramural Hematoma and Ten Years Treatment Outcomes. *World Journal of Cardiovascular Diseases*, **11**, 58-68.
https://doi.org/10.4236/wjcd.2021.111008

Received: December 21, 2020
Accepted: January 23, 2021
Published: January 26, 2021

Abstract

Background: Type B aortic intramural hematoma (IMH-B) is recognized as a subset of aortic dissection. The evolution of uncomplicated IMH-B is very difficult to predict. How and when to deal with this disease is unclear. The present study constructed two models to explore this problem. One is the morphology evolution model, which explored the risk factors and predictors for the IMH-B patients. Another is the predictive model confirmed the predictors and the time for invasive treatment of uncomplicated IMH-B patients. **Objective:** To explore the evolution predictors and detect the time for invasive treatment of uncomplicated IMH-B patients. **Methods:** The morphology evolution model demonstrated that all 81 patients were diagnosis with CTA images. The initial and follow-up data were retrospectively studied. The evolution data were collection and measurement from initial and follow-up CTA images data. The predictive model showed that predictors of progression were detected with cox regression analysis. **Results:** All 81IMH-B patients were followed-up ranged from 1.2 to 36 months (median, 22 months). 26 patients accepted invasive treatment (24 underwent TEVAR and 2 underwent Surgery). 55 patients received medical treatment. Invasive treatment (IT) group overall events are 1/26 (3.8%); medical treatment (MT) group overall events are 33/55 (60.0%); IT group vs. MT group: $p < 0.001$. Moreover, we found that most events related aorta occurred within 30 days. Multivariate Cox regression analysis MDAD (hazard ratio, 3.58; 95% CI, 1.25 - 5.78; $p < 0.001$), MDAHT (hazard ratio, 4.26; 95% CI, 0.85 - 7.84; $p < 0.001$), and IMH with PAU (hazard ratio, 3.58; 95% CI, 1.02 - 5.63; $p < 0.001$) were confirmed as the independent predictors. **Conclusions:** MDAD > 45 mm, MDAHT > 10 mm, and IMH with PAU may be the important predictors for uncomplicated

IMH-B patients. Most adverse aorta related events occurred within 30 days. It would be careful follow-up, closely observe for these patients within 30 days, and take necessary treatment strategies in time.

Keywords

IMH-B, Aortic Related Events, Treatment Strategies

1. Introduction

IMH-B is characterized by aortic wall hematoma without intimal tear or direct flow communication between true and false. The etiology of this disease is unclear. Some researchers reported the cause may be related to spontaneous vasa vasorum bleeding in the aortic wall media without intimal disruption [1] [2]. Some studies showed that FID, pre-existing atherosclerosis, and hypertension may be risk factors for IMH-B [3] [4]. Previous studies indicated that IMH-B may be a subset of aortic dissections with very limited flow in the false lumen [5] [6]. Moreover, the evolution of IMH-B toward progression or regression under different conditions is not clear [7] [8]; therefore, how and when to deal with IMH-B becomes a focus in the world. Our study followed up the characteristics and evolution of IMH-B patients, explored the evolution predictors and the invasive treatment time for uncomplicated IMH-B patients.

2. Methods

2.1. Patients Collection

From May 2010 to May 2020, 81 type B aortic intramural hematoma (IMH-B) patients were collected from Liuzhou municipal Liutie central hospital (19/81, 23.5%), people's hospital of Sanya city (36/81, 44.4%) and the second affiliated hospital of Shantou university medical college (26/81, 32.1%). All patients were diagnosed as type B aortic Intramural hematoma (IMH-B) with computed tomography angiography (CTA), IMH-B is noted as a descending aortic dissection without intimal tear, but now the intimal defects are detected with high-resolution computed tomography, so IMH-B may be a subset of aortic dissections with very limited flow in the false lumen. This study was approved by the ethics committees of three hospitals. The authors had full access to and take responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

2.2. Clinical Data

All patients' clinical data were collected retrospectively from the medical records. The information included age, sex, history, clinical presentation, physical examination, imaging findings, medical treatment and invasive treatment, and outcomes. All data were verified by reviewing medical records and follow up data.

2.3. Follow-up Protocol

CTA was performed in all cases. Initial CTA images were selected and measured at 3 levels to evaluate aortic diameter and hematoma thickness in the descending aorta. Among 3 slices, the largest one was defined as maximum descending aortic diameter (MDAD) and maximum descending aortic hematoma thickness (MDAHT). CTA were also follow-up to detect IMH with APU and FID evolution and outcomes.

2.4. Data Analysis

All patients' data such as presentation, physical findings, evaluation, management, and outcomes were collected. Image evolution was carefully tracked in initial and following-up patients' imaging findings and assessed the outcomes. The relationship between the data of CTA image evolution and clinical events was analysis for detecting predictors and confirming the invasive treatment time.

2.5. Statistical Analysis

All results were presented here with mean ± SEM. Comparison between two groups was evaluated by Student's t-test. One-way ANOVA was used to evaluate the significance of the difference between multiple groups. Survival curves were generated by the Kaplan–Meier method and difference in survival between groups used the log-rank test. Cox regression analysis was done to identify factors associated with the key endpoints. P values < 0.05 were considered to be statistically significant. Data analysis was performed with SPSS software (SPSS, Chicago, Illinois, version 22.0) and the survival curve of Kaplan–Meier was done with Graphpad prism 8.

3. Results

3.1. Patients Characteristics

Among the 81 patients of IMH-B, 57 (70.4%) were men and 24 (29.6%) were women, The mean age of the cohort was 67.2 ± 11.3 years. 76.5% patients of this study had history of hypertension. 26 patients accepted invasive treatment (24 underwent TEVAR and 2 underwent Surgery), there was no patient died; 55 patients received medical treatment, 7 (12.7%) died in acute and sub-acute phase and 48 survived. The survival curve of Kaplan-Meier was shown in **Figure 1**. The patients followed-up range: 1.2 - 36 months, median: 22 months. Characteristics of all patients are shown in **Table 1**.

3.2. Morphology Evolution of IMH-B

All patients were diagnosed acute IMH-B and followed up with CTA. Typical imaging data obtained between the acute phase and follow up phase. The evolution characteristics of aortic IMH, IMH with ULP and IMH with PAU, were shown in **Figures 2(A)-(H)** respectively.

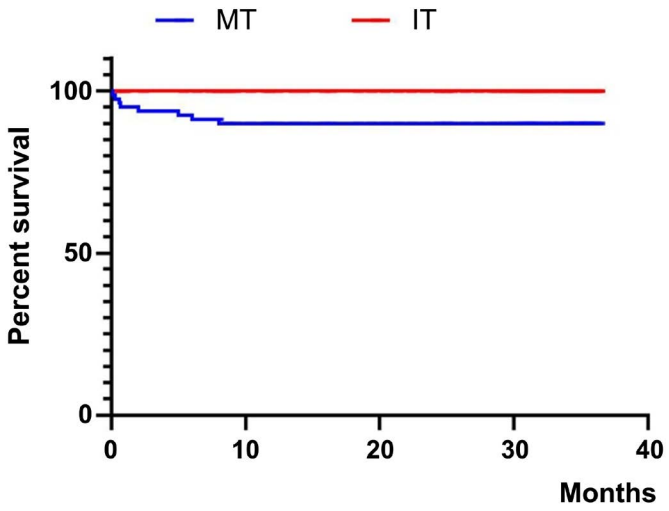

Figure 1. The Kaplan-Meier survival curves for IMH-B patients (n = 81). Compared with IT group (n = 26), the mortality of IMH-B patients of MT group was significantly high (n = 55), ($p < 0.001$).

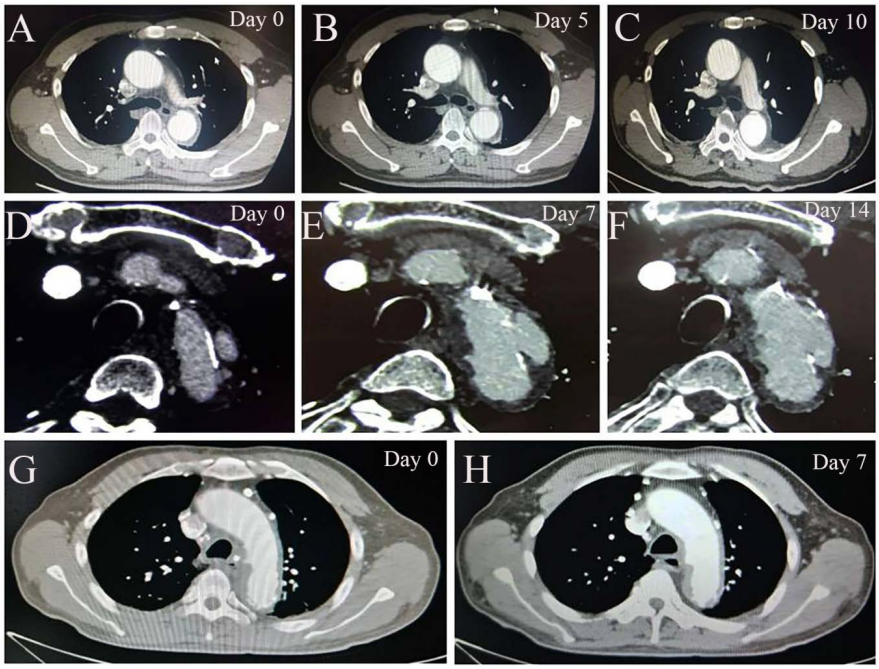

Figure 2. Morphology evolution for IMH-B patients. A - C showed Morphology evolution of IMH-B at day 0, day 5 and day 10 respectively; D - F showed Morphology evolution of ULP at day 0, day 7 and day 14 respectively; G - H showed Morphology evolution of PAU at day 0 and day 7.

Table 1. The baseline characteristics of IMH-B patients (n = 81).

Patients characteristics	variable
Demographic and history	
Age, y	67.2 ± 11.3
Men, n (%)	57 (70.4)

Continued

Hypertension, n (%)	62 (76.5)
Diabetes, n (%)	21 (25.9)
Smoker, n (%)	30 (37.0)
Pleural effusion, n (%)	7 (8.64)
Myocardial ischemia, n (%)	2 (2.46)
Mesenteric ischemia, n (%)	1 (1.23)
Medical treatment	
Calcium antagonists, n (%)	71 (87.7)
ACE-inhibitors, n (%)	12 (14.8)
Beta-blockers, n (%)	65 (80.2)
Nitrates, n (%)	32 (39.5)
Statins, n (%)	21 (25.9)
Antiplatelet agents, n (%)	13 (16.0)
Physical examination	
Heart rate, n (%)	109.4 ± 14.3
Systolic Blood pressure, mmHg	156.7 ± 12.4
Diastolic Blood pressure, mmHg	86.2 ± 9.6
SpO_2, n (%)	88 ± 7.4
ECG findings	
Normal, n (%)	70 (86.4)
Atrial fibrillation, n (%)	4 (5.93)
ST segment change, n (%)	6 (7.41)
Q wave, n (%)	1(1.23)
Chest x-ray findings	
Normal, n (%)	65 (80.2)
Widened mediastinum, n (%)	5 (6,17)
Abnormal heart contour, n (%)	7 (8.64)
Pleural effusion, n (%)	4 (5.93)
Lab examination	
WBC, 10^9/L	11.2 ± 3.6
PLT, 10^9/L	282.5 ± 71.9
HG, g/L	128.3 ± 21.7
CKMB, ng/ml	12.7 ± 5.9
ALT, U/L	36.8 ± 11.9
AST, U/L	31.6 ± 7.4
BUN, mmol/L	6.5 ± 2.7
CR, mmol/L	81.7 ± 5.9
CRP, mg/dl	32.7 ± 6.4
D-dimer, ng/ml	4.2 ± 1.1

3.3. Progression Data Analysis

All Patients' variety of CTA image data and morphological evolution model of IMH-B were shown in Table 2. The data indicated that MDAD < 35 mm, 82.1% Patients regression, 17.9% Patients progression ($p < 0.001$), and MDAHT < 6 mm, 73.3% Patients regression. 26.7% Patients progression ($p < 0.05$). However, when MDAD > 45 mm, 16.7% Patients regression, 83.3% Patients regression ($p < 0.001$), and MDAHT > 10 mm, 0 Patients regression, 100% Patients regression ($p < 0.001$). We also found that IMH-B with FID, 31.8% Patients regression, 68.2% Patients progression ($p < 0.05$), and IMH-B with PAU, 18.1% Patients regression, 81.9% Patients progression ($p < 0.001$). The model demonstrated that MDAD > 45 mm, MDAHT > 10 mm, IMH-B with FID, and IMH-B with PAU may be the risk factors for IMH-B patients.

3.4. Predictors of Progression

Aorta related events were demonstrated in the predictive model (Table 3). In 81 patients, 26 patients were treated with invasive treatment overall events 1, 26 (3.8%), And 55 patients were treated with medical treatment overall events 33, 55 (60.0%) $p < 0.001$, we found that most events related to aortia were occurrence in early 30 days. Among 55 patients, 12 patients were progressed to AD. 10 patients were progressed to periaortic hemorrhage, 4 patients were progressed to pleural effusion, and 7 patients were dead. Compared with invasive treatment group, 1 patient was progressed to AD $p < 0.001$, 0 patients were progressed to periaortic hemorrhage $p < 0.001$, 0 patients were progressed to pleural effusion $p < 0.001$, and 0 patients were dead $p < 0.001$. Univariate analysis showed MDAD, MDAHT, IMH with AUP, IMH with FID as the significant predictors. Multivariate Cox regression analysis MDAD (hazard ratio, 3.58; 95% CI, 1.25 - 5.78; $p < 0.001$), MDAHT (hazard ratio, 4.26; 95% CI, 0.85 - 7.84; $p < 0.001$), and IMH with PAU (hazard ratio, 3.58; 95% CI, 1.02 - 5.63; $p < 0.001$) were confirmed as the independent predictors of early and late progression (Table 4).

Table 2. The morphological evolution model (n = 81).

IMH-B	variates	N (%)	Regression n (%)	Progression (%)	P value
MDAD, mm	MDAD < 35	28 (34.6)	23 (82.1)	5 (17.9)	<0.001
	35 < MDAD < 40	31 (38.3)	23 (74.2)	8 (25.8)	0.037
	40 < MDAD < 45	16 (19.8)	7 (43.6)	9 (56.4)	0.642
	MDAD > 45	6 (7.4)	1 (16.7)	5 (83.3)	<0.001
MDAHT, mm	MDAHT < 6	30 (37.0)	22 (73.3)	8 (26.7)	0.042
	6 < MDAHT < 8	27 (33.3)	17 (56.7)	7 (43.3)	0.708
	8 < MDAHT < 10	19 (23.5)	8 (42.1)	11 (57.9)	0.620
	MDAHT > 10	5 (6.2)	0 (0)	5 (100)	<0.001
FID	Without FID	59 (72.8)	36 (61.0)	23 (39.0)	0.055
	With FID	22 (27.2)	7 (31.8)	15 (68.2)	0.048
PAU	Without PAU	70 (86.4)	49 (70.0)	21 (30.0)	0.053
	With PAU	11 (13.6)	2 (18.1)	9 (81.9)	<0.001

Two groups were evaluated by Student's t-test and multiple groups by One-way ANOVA.

Table 3. The predictive model (n = 81).

Time/Aorta related events	Medical treatment, n, N (%)	Invasive treatment, n, N (%)	P value
The acute phase (1 - 14 days)			
AD	5.55 (9.1%)	0.26 (0)	<0.001
Periaortic hemorrhage	5.55 (9.1%)	0.26 (0)	<0.001
Pleural effusion	1.55 (1.8%)	0.26 (0)	
Death	3.55 (1.8%)	0.26 (0)	
The subacute phase (15 - 30 days),			
AD	5.42 (11.9%)	1.22 (2.6%)	
Periaortic hemorrhage	2.42 (4.8%)	0.22 (0)	<0.001
Pleural effusion	2.42 (4.8%)	0.22 (0)	
Death	2.42 (4.8%)	0.22 (0)	
The follow-up phase (2 - 12 months)			
AD	1.32 (3.1%)	0.17 (0)	
Periaortic hemorrhage	2.32 (6.3%)	0.17 (0)	
Pleural effusion	1.32 (3.1%)	0.17 (0)	
Death	2.32 (6.3%)	0.17 (0)	
The follow-up (13 - 24 months)			
AD	1.27 (3.7%)	0.12 (0)	
Periaortic hemorrhage	0.27 (0)	0.12 (0)	
Pleural effusion	0.27 (0)	0.12 (0)	
Death	0.27 (0)	0.12 (0)	
The follow-up (25 - 36 months)			
AD	0.23 (0)	0.6 (0)	
Periaortic hemorrhage	1.23 (4.3%)	0.6 (0)	
Pleural effusion	0.23 (0)	0.6(0)	
Death	0.23 (0)	0.6 (0)	.
Overall events	33.55 (60.0%)	1.26 (3.8%)	<0.001
AD	12.55 (30.9%)	1.26 (0)	<0.001
Periaortic hemorrhage	10.55 (18.2%)	0.26 (0)	<0.001
Pleural effusion	4.55 (7.3%)	0.26 (0)	<0.001
Death	7.55 (12.7%)	0.26 (0)	<0.001

Two groups were evaluated by Student's t-test and multiple groups by One-way ANOVA.

Table 4. Predictors analysis for IMH-B patients (n = 81).

	Univariate predictors		Multivariate predictors	
	Hazard Ratio (95% CI)	P value	Hazard Ratio (95% CI)	P value
Age	1.16 (0.72 - 1.93)	0.28		
Men	1.52 (0.81 - 2.27)	0.31		
Hypertension	0.65 (0.24 - 2.12)	0.42		
Diabetes	1.03 (0.74 - 2.53)	0.53		
Smoker	1.02 (0.71 - 3.26)	0.77		

Continued

Pleural effusion	3.56 (0.58 - 4.13)	0.003		
MDAD (>45 mm)	4.19 (0.32 - 7.42)	<0.001	3.58 (1.25 - 5.78)	<0.001
MDAHT (>10 mm)	5.42 (1.72 - 7.03)	<0.001	4.26 (0.85 - 7.84)	<0.001
Periaortic hemorrhage	3.06 (0.96 - 6.39)	0.006		
IMH with PAU	4.17 (2.12 - 8.47)	<0.001	3.26 (1.02 - 5.63)	<0.001
IMH with FID	4.38 (1.25 - 6.31)	<0.001		

Cox-regression analysis.

4. Discussion

The findings of present study were as follows: MDAD > 45 mm, MDAHT > 10 mm, and IMH with PAU may be the important predictors for uncomplicated IMH-B patients. Most adverse aorta related events occurred within 30 days. It would be careful follow-up, closely observe for these patients within 30 days, and take necessary treatment strategies in time.

There has been a controversy regarding the treatment of IMH-B. The mainly treatment strategy for IMH-B was medical treatment, However, the evolution of IMH-B appears to be more progression related events than that of invasive treatment group [9] [10]. In present report, we constructed morphology evolution model to IMH-B patients and observed progression related events. Our data was shown total 81 patients, 26 patients were treated with invasive treatment overall events 1, 26 (3.8%), And 55 patients were treated with medical treatment overall events 33, 55 (60.0%) $p < 0.001$. Among 55 patients, 12 patients were progressed to AD. 10 patients were progressed to periaortic hemorrhage, 4 patients were progressed to pleural effusion, and 7 patients were dead. Compared with invasive treatment group, 1 patient was progressed to AD $p < 0.001$, 0 patients were progressed to periaortic hemorrhage $p < 0.001$, 0 patients were progressed to pleural effusion $p < 0.001$, and 0 patients were dead $p < 0.001$. If IMH-B become IMH-A or type A aortic dissection. Surgery would be performed in time. 26 patients received invasive treatment, 24 patients underwent TEVAR and 2 surgeries in our study. IMH-B is most often a progressive disease. In case of complications, invasive treatment would be a good method in most high risk cases.

However, how to confirm the invasive treatment indications and when to select treatment strategies are the major difficulties for IMH-B patients. It has been reported that adverse aortic-related events could help risk stratification and management decisions [11] [12] [13]. Some researchers indicated that most of the adverse aorta-related events happened within 1 month during follow-up [11] [14] [15]. In the present study, we constructed the predictive models for IMH-B patients, screened the morphology evolution of IMH-B patients. The data indicated that MDAD < 35 mm, 82.1% Patients regression, 17.9% Patients progression ($p < 0.001$), and MDAHT < 6 mm, 73.3% Patients regression. 26.7% Patients progression ($p < 0.05$). However, when MDAD > 45 mm, 16.7% Patients regression, 83.3% Patients regression ($p < 0.001$), and MDAHT > 10 mm, 0 Pa-

tients regression, 100% Patients regression ($p < 0.001$). We also found that IMH-B with FID, 31.8% Patients regression, 68.2% Patients progression ($p < 0.05$), and IMH-B with PAU, 18.1% Patients regression, 81.9% Patients progression ($p < 0.001$). In order to find out the relationship between the morphology evolution of IMH-B and aorta related events for the IMH-B patients, we explored predictors of progression in aorta related events model, In 81 patients, 26 patients were treated with invasive treatment overall events 1, 26 (3.8%), And 55 patients were treated with medical treatment overall events 33, 55 (60.0%) $p < 0.001$. Among 55 patients, 12 patients were progressed to AD. 10 patients were progressed to periaortic hemorrhage, 4 patients were progressed to pleural effusion, and 7 patients were dead. Compared with invasive treatment group, 1 patient was progressed to AD $p < 0.001$, 0 patients were progressed to periaortic hemorrhage $p < 0.001$, 0 patients were progressed to pleural effusion $p < 0.001$, and 0 patients were dead $p < 0.001$. Univariate analysis showed MDAD, MDAHT, IMH with AUP, IMH with FID as the significant predictors. Multivariate Cox regression analysis MDAD (hazard ratio, 3.58; 95% CI, 1.25 - 5.78; $p < 0.001$), MDAHT (hazard ratio, 4.26; 95% CI, 0.85 - 7.84; $p < 0.001$), and IMH with PAU (hazard ratio, 3.58; 95% CI, 1.02 - 5.63; $p < 0.001$) were confirmed as the independent predictors of early and late progression.

5. Limitations

We constructed initial two models for the present retrospective observational study. The mainly limitations are as follows: Firstly, the number of patients enrolled was small, which might have data selection and analysis bias. Secondly, most events related aorta occurred in acute and sub-acute phase (within 30 days). How to confirm the exact time for each IMH-B patient is required investigation. Finally, the two models need to be further improved and a large-scale randomized control trial is required.

6. Conclusions

1) MDAD > 45 mm, MDAHT > 10 mm, and IMH with PAU may be the independent risk predictors for uncomplicated IMH-B patients.

2) In acute IMH-B, most adverse aorta related events occurred within 30 days.

3) Invasive treatment may be the safe and effective way for high risk IMH-B patients.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bischoff, M.S., Meisenbacher, K., Wehrmeister, M., Böckler, D. and Kotelis, D. (2016) Treatment Indications for and Outcome of Endovascular Repair of Type B Intramural Aortic Hematoma. *Journal of Vascular Surgery*, **64**, 1569-1579.

https://doi.org/10.1016/j.jvs.2016.05.078

[2] Evangelista, A., Mukherjee, D., Mehta, R.H., O'Gara, P.T., Fattori, R., Cooper, J.V., Smith, D.E., Oh, J.K., Hutchison, S., Sechtem, U., Isselbacher, E.M., Nienaber, C.A., Pape, L.A. and Eagle, K.A. (2005) Acute Intramural Hematoma of the Aorta: A Mystery in Evolution. *Circulation*, **111**, 1063-1070. https://doi.org/10.1161/01.CIR.0000156444.26393.80

[3] Bossone, E., Cocchia, R., Ranieri, B. and Eagle, K. (2019) Type B Intramural Hematomas and Penetrating Aortic Ulcers: Clinical Comment on Management and Outlook. *Annals of Cardiothoracic Surgery*, **8**, 490-491. https://doi.org/10.21037/acs.2019.05.14

[4] Tittle, S.L., Lynch, R.J., Cole, P.E., Singh, H.S., Rizzo, J.A., Kopf, G.S. and Elefteriades, J.A. (2002) Midterm Follow-Up of Penetrating Ulcer and Intramural Hematoma of the Aorta. *The Journal of Thoracic and Cardiovascular Surgery*, **123**, 1051-1059. https://doi.org/10.1067/mtc.2002.121681

[5] Kaji, S., Akasaka, T., Horibata, Y., Nishigami, K., Shono, H., Katayama, M., Yamamuro, A., Morioka, S., Morita, I., Tanemoto, K., Honda, T. and Yoshida, K. (2002) Long-Term Prognosis of Patients with Type A Aortic Intramural Hematoma. *Circulation*, **106**, I248-I252.

[6] Oderich, G.S., Kärkkäinen, J.M., Reed, N.R., Tenorio, E.R. and Sandri, G.A. (2019) Penetrating Aortic Ulcer and Intramural Hematoma. *Cardio Vascular and Interventional Radiology*, **42**, 321-334. https://doi.org/10.1007/s00270-018-2114-x

[7] Weiss, S., Sen, I., Huang, Y., Killian, J.M., Harmsen, W.S., Mandrekar, J., Chamberlain, A.M., Goodney, P.P., Roger, V. and DeMartino, R.R. (2019) Cardiovascular Morbidity and Mortality after Aortic Dissection, Intramural Hematoma, and Penetrating Aortic Ulcer. *Journal of Vascular Surgery*, **70**, 724-731. https://doi.org/10.1016/j.jvs.2018.12.031

[8] Evangelista, A., Maldonado, G., Moral, S., Teixido-Tura, G., Lopez, A., Cuellar, H. and Rodriguez-Palomares (2019) Intramural Hematoma and Penetrating Ulcer in the Descending Aorta: Differences and Similarities. *Annals of Cardiothoracic Surgery*, **8**, 456-470. https://doi.org/10.21037/acs.2019.07.05

[9] Moizumi, Y., Komatsu, T., Motoyoshi, N. and Tabayashi, K. (2004) Clinical Features and Long-Term Outcome of Type A and Type B Intramural Hematoma of the Aorta. *The Journal of Thoracic and Cardiovascular Surgery*, **127**, 421-427. https://doi.org/10.1016/j.jtcvs.2003.09.016

[10] Tanaka, A., Leake, S. and Estrera, A.L. (2017) Management Strategies in Acute Type B Aortic Intramural Hematoma. *Current Opinion in Cardiology*, **32**, 687-691. https://doi.org/10.1097/HCO.0000000000000453

[11] Liu, J., Liu, Y., Yang, W., Gu, J. and Xue, S. (2019) Five-Year Outcomes after Thoracic Endovascular Aortic Repair of Symptomatic Type B Penetrating Aortic Ulcer with Intramural Hematoma in Chinese Patients. *Journal of Thoracic Disease*, **11**, 206-213. https://doi.org/10.21037/jtd.2018.12.86

[12] Berger, T., Rylski, B., Beyersdorf, F. and Czerny, M. (2019) Type B Intramural Hematoma and Descending Penetrating Aortic Ulcer. *Annals of Cardiothoracic Surgery*, **8**, 488-489. https://doi.org/10.21037/acs.2019.04.09

[13] Sailer, A.M., Nelemans, P.J., Hastie, T.J., Chin, A.S., Huininga, M., Chiu, P., Fischbein, M.P., Dake, M.D., Miller, D.C., Schurink, G.W. and Fleischmann, D. (2017) Prognostic Significance of Early Aortic Remodeling in Acute Uncomplicated Type Baortic Dissection and Intramural Hematoma. *The Journal of Thoracic and Cardiovascular Surgery*, **154**, 1192-1200. https://doi.org/10.1016/j.jtcvs.2017.04.064

[14] Houben, I.B., van Bakel, T.M.J. and Patel, H.J. (2019) Type B intramural Hematoma: Thoracic Endovascular Aortic Repair (TEVAR) or Conservative Approach? *Annals of Cardiothoracic Surgery*, **8**, 483-487. https://doi.org/10.21037/acs.2019.05.18

[15] Li, Z., Lu, B., Chen, Y., Hou, Z., Chen, B., Zhang, Y., An, Y. and Wei, Y. (2019) Acute Type B Aortic Intramural Hematoma: The Added Prognostic Value of a Follow-Up CT. *European Radiology*, **29**, 6571-6580. https://doi.org/10.1007/s00330-019-06254-0

Abbreviations

TEVAR: thoracic endovascular aortic repair

IT: invasive treatment

MT: medical treatment

IMH-B: Type B intramural hematoma

PAU: penetrating aortic ulcer

ULP: ulcer like projection

CTA: computed tomography angiography

AD: aortic dissection

MDAD: maximum descending aortic diameter

MDAHT: maximum descending aortic hematoma thickness