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Risk stratification of best medical therapy for acute uncomplicated type B intramural hematoma

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ABSTRACT

Objectives: Best medical therapy (BMT) for acute uncomplicated type B intramural hematoma (TBIMH) is the current treatment guideline, but there is considerable controversy about subsequent clinical course and outcome, which may be associated with a significant failure rate. The purpose of this study was to identify potential risk factors for BMT failure and to develop a risk score to guide clinical decision making.

Methods: Patients with acute uncomplicated TBIMH between 2011 January and 2020 December were retrospectively studied. Logistic regression was applied to univariately assess potential risk predictors, and multivariable model results were then used to formulate a simplified predictive model for BMT failure.

Results: In a total of 61 patients, the overall rate of BMT failure was 57.4% (35/61), of which 48.6% (17/35) occurred within 28 days of onset. Logistic regression identified maximum descending aortic diameter (HR = 1.99 CI = 1.16–3.40, p = 0.012), initial IMH thickness (HR = 3.29, CI = 1.28–8.46, p = 0.013) and presence of focal contrast enhancement (HR = 3.12, CI = 1.49–6.54, p = 0.003) as potential risk predictors of BMT failure. A risk score was calculated as follows: [Max DTA diameter (mm)*0.6876 + Max IMH thickness (mm)*1.1918 + PAU/ULP *1.1369]. Freedom from BMT failure at 1 year was 72% in patients with a risk score < 4.12, compared with only 35.1% in those with a risk score ≧ 4.12.

Conclusions: In a substantial proportion of patients with acute uncomplicated TBIMH, initial BMT failed. Based on the three initial computed tomographic imaging variables, this risk score could help stratify patients at high or low risk for BMT failure and provided additional information for early intervention.

Introduction

Acute aortic syndrome (AAS) encompasses a spectrum of pathological processes, including aortic dissection, intramural hematoma (IMH), and penetrating aortic ulcer (PAU) [1,2]. Patients with uncomplicated type B intramural hematoma (TBIMH) are initially treated with best medical therapy (BMT) and undergo serial imaging surveillance. However, the natural course of TBIMH is unpredictable, and several studies have reported a high failure rate for BMT. With improved imaging technology and resolution, more focal intimal disruptions have been detected, which significantly increase the risk of disease progression into dissection, aneurysmal dilatation, and aortic rupture. Therefore, there is increasing consideration of thoracic endovascular aortic repair (TEVAR) for TBIMH [3–5]. Based on these observations, early TEVAR may be beneficial for selected patients with TBIMH who are at risk of disease progression; however, the indications for this intervention remain controversial. In

Abbreviations: AAA, Abdominal aortic aneurysm; AAS, Acute aortic syndrome; BMT, Best medical therapy; DTA, Descending thoracic aorta; TEVAR, Thoracic Endovascular Aneurysm Repair; FCE, Focal contrast enhancement; FET, Frozen elephant boot; IBP, Intramural blood pool; IMH, Intramural hematoma; PAU, Penetrating atherosclerotic ulcer; TBIMH, Intramural hematoma type B; ULP, Ulcerative protrusion; ICU, Intensive care unit; CT, Computed tomography.

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clinical practice, computed tomography (CT) is the most commonly used imaging modality for the initial evaluation of aortic pathologies. The aim of this study was to analyze CT morphological predictors and risk score stratification to predict patients who are more likely to fail initial BMT, where more frequent surveillance and endovascular intervention may be warranted.

Materials and methods

This study was a single center retrospective observational analysis. The study was approved by the institutional review board (NTUH-202104054RINB), and informed consent was waived. A list of patients with a diagnosis of AAS, treated at our institution from 2011 January to 2020 December, was obtained from our institutional integrated database. Individual medical records and CT images were reviewed to identify patients with uncomplicated Stanford type B aortic IMH. Patients with the following characteristics were excluded from our study: (1) complicated TBIMH (defined by initial presentation with clinical/radiological malperfusion or aortic rupture) who had received urgent surgical or endovascular intervention, (2) trauma-related (3) retrograde type A IMH.

Patients were divided into two groups. Group 1 consisted of patients who were initially treated with BMT but failed BMT and subsequently underwent TEVAR. In contrast, patients in group 2 were successfully treated with BMT and had remained stable during follow-up without further endovascular or surgical intervention. Patients with the following characteristics were considered BMT failures and were indicated for endovascular intervention: 1. Worsening refractoriness or persistent pain or uncontrollable hypertension not due to a cause other than IMH, despite adequate blood pressure and pain control 2. Increase in IMH thickness, presence of periaortic hematoma, or progression to classic aortic dissection on two consecutive images CT during the index hospitalization or follow-up ≧5 mm in 6 months 3. increase in maximum DTA diameter to ≧55 mm or an increase of ≧5 mm within 6 months 4. New or increased focal contrast enhancement (FCE), including preexisting ulcerative projections (ULP) or penetrating aortic ulcers (PAU) 5. New evidence of end-organ malperfusion. Early and late failure were defined as BMT failure occurring at or after less than 28 days. Clinical data, including demographics, underlying comorbidities, and follow-up outcomes, were collected. The primary end point was BMT failure, and secondary end points included all-cause mortality and aortic-related mortality. Aortic-related mortality was defined as death from aortic rupture, malperfusion, or aortic dissection. The cause of death of our patients was confirmed by reviewing the death certificate and medical records.

All patients with uncomplicated TBIMH confirmed by contrast and non-contrast scans CT were admitted to the intensive care unit (ICU) for intensive medical monitoring. Consistent with the management of aortic dissection, drug therapy with pulse-inhibiting agents and pain control was initiated to achieve a systolic blood pressure between 100 and 120 mmHg and a heart rate below 60 beats/min by intravenous infusion of labetalol, with second-line nicardipine and appropriate analgesics as needed. If the target blood pressure could not be achieved, additional intravenous antihypertensives were prescribed. During the index hospitalization, CT scans were repeated if the patient had symptoms such as persistent/exacerbating/new pain or concerns about end-organ dysfunction, or one week after admission if no symptoms occurred. All CT images were reviewed by a consultant radiologist and vascular surgeon. Any discrepancy in CT findings was reconciled by a third radiologist with experience in interpreting aortic images CT. TBIMH was defined as hyperdense, crescent-shaped hemorrhage within the aortic wall in the non-contrast phase, without subsequent enhancement on contrast images, affecting zone 1 or beyond. A ULP was defined as a "localized, contrast-filled sac-like pouch protruding from the aortic lumen into the IMH." If a ULP was associated with a focal intimal irregularity or adjacent atherosclerotic plaque, it was classified as PAU. The presence of an intra-mural blood pool (IBP), defined as a medium-filled space within the IMH with no or only a tiny intimal defect gap communicating with the aortic lumen, was not considered a BMT failure in this study [6].

The main techniques of TEVAR have been described previously [7]. Briefly, proximal sealing should be performed at least 2 cm proximal to the most cephalad extent of the IMH, with an oversize of no more than 10% of the true lumen diameter. If an inadequate landing zone was identified, supra-aortic debranching or chimney stent placement was performed. The distal edge of the stent graft should be at least 2 cm distal to the FCE or above the celiac trunk, depending on whether an FCE is present or not. Follow-up examinations CT were performed at 3, 6, 12 months and annually thereafter. Maximal IMH thickness and DTA diameter were measured on a central measurement line orthogonal to the axis of the aorta and compared on the same plane as at the first preoperative scan.

Statistical analysis

Normally distributed continuous variables were expressed as mean ± standard deviation (SD). Non-normally distributed continuous variables were reported as median and 25–75% interquartile range (IQR). Categorical variables were expressed as numbers and percentages. All-cause mortality, aortic-related mortality, and freedom from BMT failure were modeled using the Kaplan–Meier method, and the log-rank test was used to discriminate between Kaplan–Meier curves. Multivariable Cox regression analysis was used to analyze the risk factors associated with BMT failure and subsequent conversion to surgery. Regression coefficients for the correlated risk factors were determined. A risk score was derived as follows: Maximum DTA diameter (mm)*coefficient + Maximum IMH thickness (mm)*coefficient + PAU/ULP *coefficient. In patients in whom BMT failed early, logistic regression was performed to analyze the potential predictors. All statistical analyzes were performed with MedCalc statistical software version 20.015 (MedCalc Software, Ostend, Belgium).

Results

A total of 63 patients were identified. 61 patients received BMT as initial treatment on admission. BMT failed in 35 of them, and all of these patients subsequently underwent TEVAR (group 1). The remaining 26 patients received BMT only, without further endovascular intervention during the follow-up period (group 2). Two patients with complicated TBIMH who underwent TEVAR were excluded from the study (Fig. 1). The demographic data and baseline morphology CT of these two groups of patients are shown in Table 1. Hypertension was present in 80% of patients in group 1 and in 53.8% in group 2. Regarding the baseline morphology of CT at presentation, a larger maximum DTA diameter (3.74 ± 0.54 mm vs. 3.32 ± 0.45 mm, $p = 0.002$), a thicker IMH (1.09 ± 0.31 mm vs. 0.89 ± 0.38 mm) and more FCE (72.4% vs. 34.6%) were observed in group 1.

In our cohort, the median follow-up time was 39.2 months (IQR 22.750 to 75.367). The overall rate of BMT failure was 57.4% (35/61). Early failure occurred in 17 of 61 patients (27.9%) and late failure in 18 of 61 patients (29.5%). In patients with early BMT failure, the median time to failure and subsequent intervention was 10 days (IQR 6–18) from symptom onset, and the most common causes of failure included refractory pain (7/17), newly developed (4/17), or enlarged FCE (4/17). Among cases with late BMT failure, the median interval between symptom onset and subsequent intervention (endovascular or surgical) was 156 days (IQR 40–511). Progressive aneurysmal dilatation of the DTA (4/18), a newly formed FCE (3/18), or enlargement of a preexisting FCE (9/18) were the most common causes of failure (Table 2). In our cohort, freedom from aorta-related events in patients initially treated with BMT was 50.4% and 29.8% at 12 months and 36 months, respectively (Fig. 2). However, during long-term follow-up, no aorta-related mortality occurred in any of our patients.

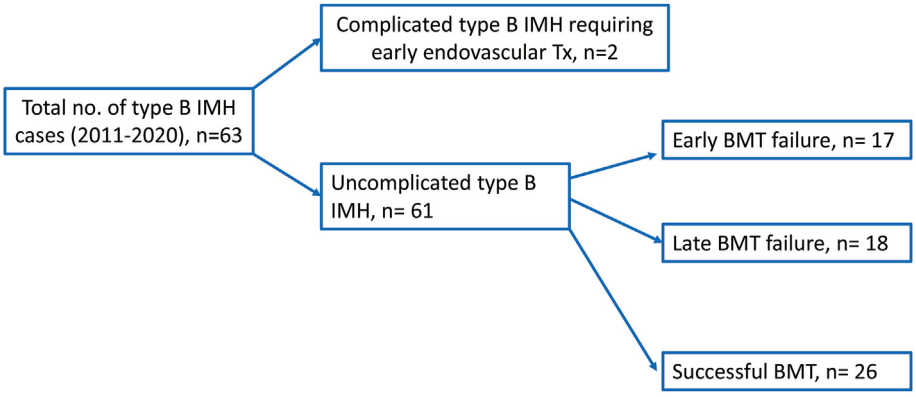

Fig. 1. The flow chart of patient enrollment. BMT best medical therapy, IMH intramural hematoma.

Predictors of BMT failure

In patients who failed initial BMT, the maximum diameter of the DTA (HR1.07, 95% CI 1.0124–1.1252, p = 0.02), the thickness of the IMH (HR 1.1221, 95% CI 1.0212–1.2329, p = 0,02) and the presence of FCE (HR 3.031, 95%CI 1.4439–6.363, p = 0.003) on the initial CT at presentation were potential negative predictors of BMT failure in univariate analysis. After multivariable Cox regression analysis, initial maximum DTA diameter (HR 2.514, 95%CI 1.3739–4.6001, p = 0.003) and the presence of FCE (HR 3.9076, 95%CI 1.772–8.617, p < 00.001) were correlated with BMT failure. There was a trend toward an increased risk of BMT failure for patients with increased IMH thickness (HR 2.8598, 95% CI 0.9084–9.0033, p = 0.07), but this did not reach statistical significance (Table 3).

To analyze the synergistic effects of the potential risk factors for BMT failure, a risk score was derived from the Cox regression coefficient of the following predictors: initial maximum DTA diameter/initial maximum IMH thickness/presence of FCE. The derived formula for the risk score was as follows: maximum DTA diameter (mm)*0.6876 + maximum IMH thickness (mm)*1.1918 + PAU/ULP *1.1369. A risk score was calculated for all 61 patients in our cohort, and a cut-off value of 4.12 was selected on the basis of receiver operating characteristic analysis (ROC), which had a sensitivity of 77.14%, a specificity of 73.08%, and a positive likelihood ratio (LR +) of 2.87 (Fig. S1). We then divided our patient cohort into 2 groups (score ≧ 4.12, score <4.12), and we found that patients with a higher risk score were significantly less likely to fail BMT (Fig. 3). Freedom from BMT failure at 1 year was 72% in patients with a

Table 1
Clinical and imaging characteristics of patients with acute uncomplicated type B intramural hematoma (TBIMH).

Characteristics	All (n = 61)	BMT + TEVAR (n = 35)	BMT alone (n = 26)
Age	66.98 ± 9.48	66.45 ± 9.25	67.71 ± 9.92
Male Sex	40 (65.6)	22 (62.9)	18 (69.2)
Comorbidities			
CAD	4 (6.6)	2 (5.7)	2 (7.7)
Post-CABG	0	0	0
Post-PCI	3 (4.9)	2 (5.7)	1 (3.8)
Diabetes mellitus	10 (16.4)	5 (8.2)	5 (19.2)
Hypertension	42 (68.9)	28 (80)	14 (53.8)
Dyslipidemia	9 (14.8)	5 (8.2)	4 (15.4)
COPD	4 (6.6)	3 (8.6)	1 (3.8)
Cirrhosis	0	0	0
Carotid stenosis	1 (1.6)	0	1 (3.8)
Chronic kidney disease	5 (8.2)	5 (8.2)	0
PAOD	1 (1.6)	1 (2.9)	0
Hx of TIA/Stroke	0	0	0
Smoking	21 (34.4)	14 (40)	7
Medication			
Beta-blocker	51 (83.6)	27 (77.1)	24 (92.3)
Anti-platelet	30 (49.1)	19 (54.3)	11 (42.3)
Anti-coagulation	1 (1.6)	0	1 (3.8)
ACEI/ARB	45 (73.8)	26 (74.3)	19 (73.1)
Statin	23 (37.7)	12 (34.3)	11 (42.3)
White cell count (K/μL)	10.36 ± 3.42	10.36 ± 3.53	10.35 ± 3.33
Serum Creatinine (mg/dL)	1.11 ± 1.13	1.26 ± 1.44	0.88 ± 0.20
Baseline CT morphology			
Max DTA diameter (cm)	3.56 ± 0.54	3.74 ± 0.54	3.32 ± 0.45
Max IMH thickness (cm)	1.0 ± 0.35	1.09 ± 0.31	0.89 ± 0.38
IMH extent (Zone)			
Involvement of the abdominal aorta (zone 6 or below)	43 (70.5)	25 (71.4)	18 (69.2)
Focal contrast enhancement (PAU/ULP)	34 (55.7)	25 (71.4)	9 (34.6)
PAU progression	23 (37.7)	22 (62.9)	1 (3.8)
Radiological malperfusion	2 (3.3)	2 (5.7)	0

Values are presented as median (IQR) for continuous variables. Categorical variables are presented as n (%). BMT best medical therapy, TEVAR thoracic endovascular aortic repair, CAD coronary artery disease, CABG coronary artery bypass grafting, PCI primary coronary intervention, COPD chronic obstructive pulmonary disease, PAOD peripheral arterial occlusive disease, TIA transient ischemic attack, ACEI angiotensin converting enzyme inhibitor, ARB angiotensin receptor blocker, DTA descending thoracic aorta, IMH intramural hematoma, PAU penetrating aortic ulcer, ULP ulcer-like projection.

Table 2
Clinical outcomes and operative procedures of the 61 patients with acute type B intramural hematoma (TBIMH) treated initially with best medical therapy.

Outcomes	N = 61
Median follow-up duration (month)	39.2 (22.75–75.37)
Overall BMT failure rate (%)	35 (58.3)
Early BMT failure	17 (27.9)
Median time to early failure	10 (6–18)
Indication for conversion to TEVAR	
Refractory pain	7 (7/17 = 41.1)
Aneurysmal dilatation	2 (11.8)
Increase in IMH thickness	2
Malperfusion	2
New FCE	4 (23.5)
Progression of FCE	4
Late BMT failure	18 (29.5)
Median time to late failure	156 (40–511)
Indication for conversion to TEVAR	
Recurrent pain	3 (16.7)
Aneurysmal dilatation	4 (22.2)
Increase in IMH thickness	0
Malperfusion	0
New FCE	3 (16.7)
Progression of FCE	9 (50)
New dissection	1 (5.6)
CT morphology at the time of BMT failure	
Maximal descending aortic diameter	3.79 (3.31–4.21)
Maximal IMH thickness	0.82 (0.38–1.25)
Types of intervention	
TEVAR	30
TEVAR + EVAR	1
EVAR	2
TAAA grafting	1
Total arch + Frozen elephant trunk	1
Operative details	
Device	
Gore TAG	18
Gore Excluder	1
Medtronic Valliant	12
Medtronic Endurant	2
Cook Zenith	2
Proximal landing zone	
Zone 1	2
Zone 2	14
Zone 3	13
Zone 4	2
Zone 9	1
Debranching procedures	
Left carotid-subclavian bypass	6
Left subclavian artery chimney	7
Left common carotid artery chimney	3
Left subclavian artery fenestration	2
Length of coverage	15 (14.75–19.00)
Concomitant procedures	
EVAR for AAA	1
Left common carotid artery stenting	1
Left subclavian artery stenting	3
Left common carotid artery endarterectomy	1
Left subclavian artery embolization	5
Common iliac artery stenting	2
Left aorto-femoral bypass	1

Values are presented as median (IQR) for continuous variables. Categorical variables are presented as n (%). BMT best medical therapy, TEVAR thoracic endovascular aortic repair, FCE focal contrast enhancement, EVAR endovascular aneurysm repair, TAAA thoracoabdominal aneurysm, AAA abdominal aortic aneurysm.

lower risk score, compared with only 35.1% in those with a higher risk score.

Predictors of early BMT failure

Seventeen patients (48.6%, 17/35) experienced early BMT failure. The CT morphologies of patients with early and late BMT failure are summarized in Table 4. In a logistic regression analysis, initial maximum IMH thickness proved to be the only significant risk predictor (OR 1.3518, 95% CI 1.024.1.7844, p = 0.03). When a cut-off value of 10.00 mm was chosen based on the ROC analysis, the sensitivity was 76.47%, the specificity was 61.11%, and the positive likelihood ratio (LR +) was 2.87 (Fig. S2).

Discussion

Thoracic intramural hematoma (TBIMH) is generally considered a milder form of acute aortic syndrome and the first-line treatment is usually best medical therapy (BMT), according to current guidelines and expert consensus [8]. However, multiple studies have reported a high failure rate for BMT, ranging from 61.8% to 71.6% [3–5]. These studies have noted reasons for converting to surgical intervention such as the development of a new entry tear, progression to aortic dissection, and aneurysmal dilation. Our study found an overall failure rate of 58.3% for BMT in patients with uncomplicated TBIMH, which is consistent with previous research [9,10]. Early failure accounted for approximately half of those who failed initial BMT. Our study also revealed that patients with IMH thickness greater than 10 mm at presentation were at potential risk for early BMT failure.

According to the International Registry of Acute Aortic Dissection (IRAD) study, aortic-related adverse events occurred in 12.9% of patients and aortic-related death occurred in 29% of patients [11,12]. In our study, medically treated TBIMH patients had an overall aortic-related adverse event rate of 58.3%. However, no aortic-related deaths were observed in our patients during a median follow-up of 39.2 months. These results suggested that even in cases with aortic-related adverse events, the long-term outcome of TBIMH remains excellent if intervention is performed, which was consistent with previous research [13].

Despite having a better understanding of the disease, optimal treatment strategies, timing, and indications for endovascular intervention have yet to be established for patients with uncomplicated TBIMH. The difficulty and challenge in establishing indications for intervention are attributed to the unpredictable and dynamic natural course of TBIMH, which can unexpectedly evolve into dissection, aneurysm, or even rupture [14]. In patients presenting initially with complicated TBIMH, such as malperfusion, rapidly enlarging aortic diameter, or new ULP, early endovascular intervention is justified without controversy as the disease is unlikely to regress if left untreated. However, in uncomplicated cases, the benefits of early endovascular intervention must be weighed against potential surgical complications, such as stent graft-induced new entry tears, retrograde dissection, and spinal cord ischemia, particularly in the acute phase [8]. Therefore, reliable clinical or radiological predictors are essential in helping clinicians identify those most likely to benefit from early endovascular intervention.

To date, no specific guidance has been provided regarding the threshold for surgical intervention for “uncomplicated” TBIMH. Nevertheless, several adverse predictors have been identified as independent risk factors for disease progression, some of which were derived from studies of type A IMH. The presence of penetrating aortic ulcer (PAU) or ulcer-like projection (ULP) has been described as one of the major adverse predictors for TBIMH. A retrospective analysis of 54 patients with TBIMH found that the presence of PAU with IMH was associated with disease progression (rupture/IMH expansion/dissection) [15]. The incidence of PAU in patients with TBIMH in that study was relatively high at 57.4%. However, a clear definition of the term “PAU” was not stated in the article, so it is possible that some cases of ULP may also have been included. In our study, the rate of FCE was 55.7%, which included both PAU and ULP. We did not include IBP in our analysis due to insufficient evidence to suggest that it is associated with an increased risk of IMH progression. The clinical course of IBP is relatively benign, with complete resorption or stability in most patients [6]. IMH thickness has also been reported as a predictor of progression, with some authors proposing a cut-off >10 mm, although this threshold varies considerably between literature, ranging from 8 to 15 mm [10,16]. Several

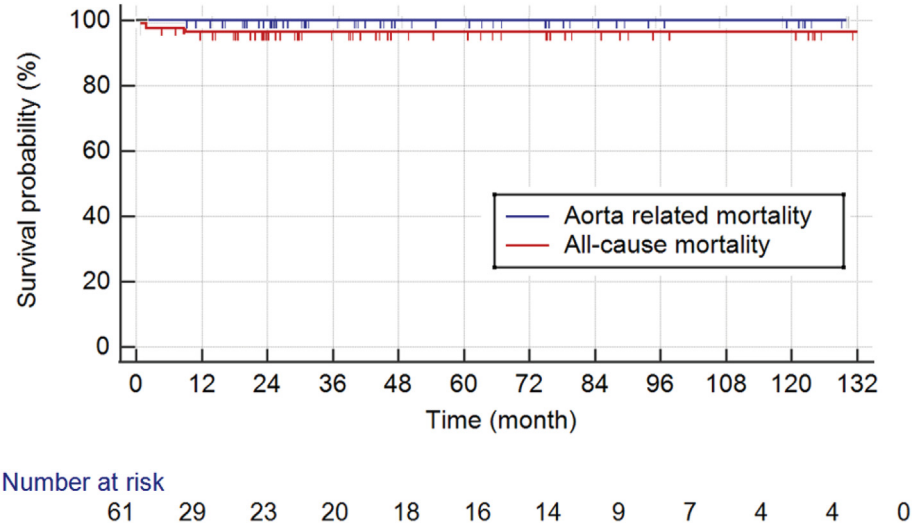

Fig. 2. Kaplan–Meier curve for freedom from all-cause mortality and aorta-related mortality in patients with acute uncomplicated type B intramural hematoma (TBIMH).

retrospective studies have described maximum aortic diameter >40–50 mm in the acute phase as a potential adverse predictor for disease progression [17,18], while some others found no association between maximum aortic diameter and IMH progression [4,15].

Our study suggested potential associations between BMT failure with greater aortic diameter, IMH thickness, and the presence of FCE on univariable analysis. Although IMH thickness did not reach statistical significance on multivariable analysis, a trend towards increased incidence for BMT failure was observed (HR 2.8598, 95% CI 0.91–9.0, p = 0.07), which might be partially attributed to the small sample size. We derived a risk score calculation from the Cox regression to stratify patients into high and low risk, as it is likely that different adverse predictors for IMH progression do not weigh the same and the presence of multiple adverse predictors might have an additive effect on subsequent outcomes. The risk score includes all potential adverse predictors and helps clinicians to stratify their patients more accurately and objectively. It is a potentially valuable tool for clinicians to prompt awareness that a patient is at a higher risk of BMT failure, where more frequent imaging surveillance or even preemptive TEVAR may be warranted.

Limitations

This study came from a single-center registry, which limits the case number. However, this study still provides valuable findings and insight as to which features constitute a high-risk feature. To our knowledge, there is currently no predictive model for uncomplicated type B IMH available, and the predictive model from our study remains a useful tool in clinical practice. In order to improve the predictive power of our

Table 3
Cox-regression analysis of risk predictors for best medical therapy (BMT) failure.

	Univariable		Multivariable	
	HR (95%CI)	p-value	HR (95%CI)	*p*-value
Age	0.99 (0.96, 1.03)	0.76		
Male Sex	0.83 (0.42, 1.66)	0.60		
Comorbidities				
CAD	0.90 (0.21, 3.76)	0.88		
Post-PCI	1.4705 (0.35, 6.18)	0.60		
Diabetes mellitus	1.22 (0.47, 3.17)	0.68		
Hypertension	2.08 (0.90–4.77)	0.09		
Dyslipidemia	0.95 (0.37, 2.47)	0.92		
COPD	2.74 (0.83, 9.08)	0.09		
Chronic kidney disease	4.32 (1.64, 11.37)	0.003		
PAOD	1.32 (0.18, 9.70)	0.78		
Smoking	1.47 (0.75, 2.90)	0.27		
Medication				
Beta blocker	0.48 (0.22, 1.074)	0.07		
Anti-platelet	1.37 (0.70, 2.69)	0.35		
ACEI/ARB	0.88 (0.41, 1.89)	0.74		
Statin	0.87 (0.43, 1.75)	0.70		
White cell count (K/μL)	1.02 (0.92, 1.12)	0.75		
Creatinine (mg/dL)	1.16 (0.94, 1.42)	0.16		
CT morphology				
Max DTA diameter (mm)*	1.99 (1.16–3.40)	0.01	2.51 (1.37–4.60)	0.003
Max IMH thickness (mm)*	3.29 (1.28–8.46)	0.01	2.86 (0.91–9.0)	0.07
Involvement abdominal Aorta	1.07 (0.51,2.24)	0.85		
PAU/ULP	3.12 (1.49–6.54)	0.003	3.91 (1.77–8.62)	<0.001

HR Hazard ratio, CI confidence interval, CAD coronary artery disease, PCI primary coronary intervention, COPD chronic obstructive pulmonary disease, PAOD peripheral arterial occlusive disease, TIA transient ischemic attack, ACEI angiotensin converting enzyme inhibitor, ARB angiotensin receptor blocker, DTA descending thoracic aorta, IMH intramural hematoma, PAU penetrating aortic ulcer, ULP ulcer-like projection.

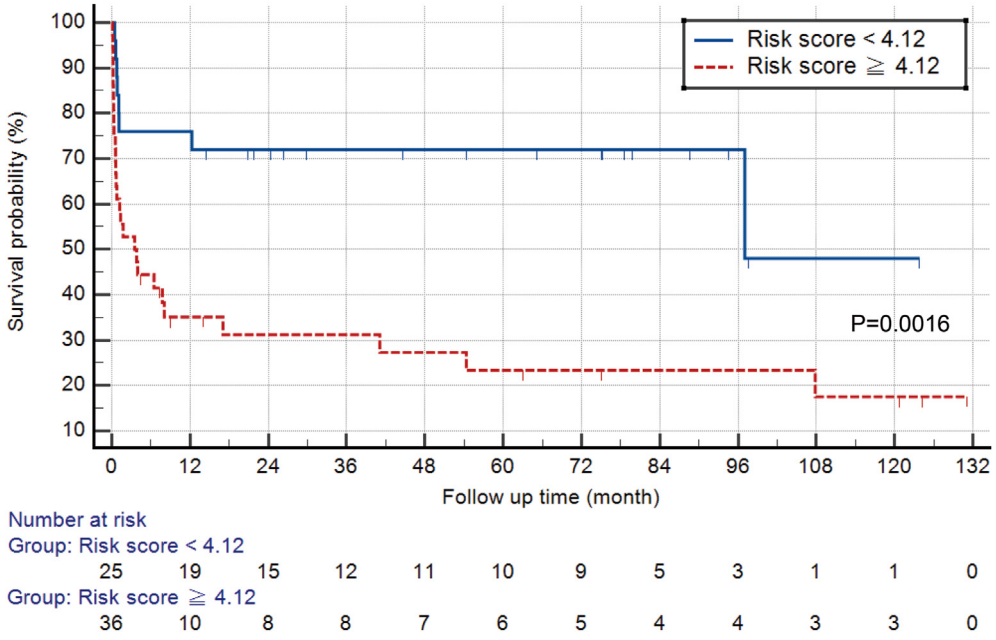

Fig. 3. Kaplan–Meier curve for freedom from best medical therapy (BMT) failure between patients with high or low risk score.

Table 4
The CT morphologies of patients with early & late best medical therapy (BMT) failure.

Group	Early failure (N = 17)	Late failure (N = 18)	Univariable Model	
			OR (95%CI)	*p*-value
Focal contrast enhancement				
(PAU/ULP)	13 (76.5%)	12 (66.7%)	1.63 (0.37, 7.20)	0.52
Max DTA diameter				
Mean (SD)	3.75 ± 0.54	3.74 ± 0.55	1.01 (0.89, 1.15)	0.86
Median (IQR)	3.55 (3.44–4.08)	3.49 (3.28–4.16)		
Max IMH thickness				
Mean (SD)	1.21 ± 0.33	0.97 ± 0.55	1.35 (1.02, 1.78)	0.03
Median (IQR)	1.16 (0.98–1.49)	0.94 (0.81–1.05)		

Initial maximal thickness of the intramural hematoma (IMH). PAU penetrating atherosclerotic ulcer, ULP ulcer like projection, DTA descending thoracic aorta, SD standard deviation, IQR interquartile range.

model, larger sample size with longer follow-up would be mandatory. We aim to advance the idea of this manuscript in our future study either by using multi-center cohort or Nation-wide health insurance database. Additionally, the study was retrospective, and selection bias was possible. Although the surgeon ultimately decided which patient would receive intervention, since the decision to intervene was not part of the study endpoint, it would not affect our study results. PAU and ULP were both classified as FCE in our study. Although there was some clinical overlap between the two entities, it remained to be determined if one might have a greater impact on our study outcome than the other [19]. The risk score also did not take into account the location, width, and depth of the FCE. Additionally, our patient population was limited to a specific ethnicity (i.e., Asian), so the applicability of the results to other ethnic groups is unknown. Finally, validation of the risk score with AI intelligence and computer learning model will be an integral part of our future study.

Conclusions

This study has demonstrated that a significant portion of patients with acute uncomplicated TBIMH experienced treatment failure after initial BMT. Maximal DTA diameter, maximal IMH thickness, and the presence of FCE were potential risk predictors. This risk score helps to stratify patients into high and low risk of BMT failure and could provide additional information regarding early intervention in patients after BMT failure, as timely endovascular intervention offered equivalent long-term aortic-related outcomes comparable to those without BMT failure.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.surge.2024.04.004.

References

[1] Evangelista A, Mukherjee D, Mehta RH, O'Gara PT, Fattori R, Cooper JV, et al. Acute intramural hematoma of the aorta: a mystery in evolution. Circulation 2005;111(8):1063–70.
[2] Tanaka A, Leake S, Estrera AL. Management strategies in acute type B aortic intramural hematoma. Curr Opin Cardiol 2017;32(6):687–91.
[3] Bischoff MS, Meisenbacher K, Wehrmeister M, Bockler D, Kotelis D. Treatment indications for and outcome of endovascular repair of type B intramural aortic hematoma. J Vasc Surg 2016;64(6):1569–15679 e2.
[4] Mesar T, Lin MJ, Kabir I, Dexter DJ, Rathore A, Panneton JM. Medical therapy in type B aortic intramural hematoma is associated with a high failure rate. J Vasc Surg 2020;71(4):1088–96.
[5] Schoenhoff FS, Zanchin C, Czerny M, Makaloski V, Gahl B, Carrel T, et al. Aorta related and all-cause mortality in patients with aortic intramural haematoma. Eur J Vasc Endovasc Surg 2017;54(4):447–53.
[6] Wu MT, Wang YC, Huang YL, Chang RS, Li SC, Yang P, et al. Intramural blood pools accompanying aortic intramural hematoma: CT appearance and natural course. Radiology 2011;258(3):705–13.
[7] Ryoi O, Lin CH, Chen JM, Hsieh YK, Wang SS, Wu IH. Endovascular repair for retrograde type A intramural haematoma with intimal tear in the descending thoracic aorta. Eur J Vasc Endovasc Surg 2020;60(3):386–93.
[8] Evangelista A, Czerny M, Nienaber C, Schepens M, Rousseau H, Cao P, et al. Interdisciplinary expert consensus on management of type B intramural haematoma and penetrating aortic ulcer. Eur J Cardio Thorac Surg 2015;47(2):209–17.
[9] Haensig M. Type B intramural hematoma: focus on reasons for development and overlapping clinical disease. Ann Cardiothorac Surg 2019;8(4):494–6.
[10] Song JK, Yim JH, Ahn JM, Kim DH, Kang JW, Lee TY, et al. Outcomes of patients with acute type a aortic intramural hematoma. Circulation 2009;120(21):2046–52.
[11] Evangelista A, Dominguez R, Sebastia C, Salas A, Permanyer-Miralda G, Avegliano G, et al. Long-term follow-up of aortic intramural hematoma: predictors of outcome. Circulation 2003;108(5):583–9.
[12] Tsai TT, Fattori R, Trimarchi S, Isselbacher E, Myrmel T, Evangelista A, et al. Long-term survival in patients presenting with type B acute aortic dissection: insights from the International Registry of Acute Aortic Dissection. Circulation 2006;114(21):2226–31.
[13] Chakos A, Twindyawardhani T, Evangelista A, Maldonado G, Piffaretti G, Yan TD, et al. Endovascular versus medical management of type B intramural hematoma: a meta-analysis. Ann Cardiothorac Surg 2019;8(4):447–55.
[14] Piffaretti G, Lomazzi C, Benedetto F, Pipito N, Castelli P, Trimarchi S, et al. Best medical treatment and selective stent-GraftRepair for acute type B aortic intramural hematoma. Semin Thorac Cardiovasc Surg 2018;30(3):279–87.
[15] Ganaha F, Miller DC, Sugimoto K, Do YS, Minamiguchi H, Saito H, et al. Prognosis of aortic intramural hematoma with and without penetrating atherosclerotic ulcer: a clinical and radiological analysis. Circulation 2002;106(3):342–8.
[16] Kitai T, Kaji S, Yamamuro A, Tani T, Tamita K, Kinoshita M, et al. Clinical outcomes of medical therapy and timely operation in initially diagnosed type a aortic intramural hematoma: a 20-year experience. Circulation 2009;120(11 Suppl):S292–8.
[17] Sueyoshi E, Imada T, Sakamoto I, Matsuoka Y, Hayashi K. Analysis of predictive factors for progression of type B aortic intramural hematoma with computed tomography. J Vasc Surg 2002;35(6):1179–83.
[18] Sueyoshi E, Onizuka H, Nagayama H, Sakamoto I, Uetani M. Clinical importance of minimal enhancement of type B intramural hematoma of the aorta on computed tomography imaging. J Vasc Surg 2017;65(1):30–9.
[19] Kitai T, Kaji S, Yamamuro A, Tani T, Kinoshita M, Ehara N, et al. Impact of new development of ulcer-like projection on clinical outcomes in patients with type B aortic dissection with closed and thrombosed false lumen. Circulation 2010;122(11 Suppl):S74–80.