

An Algorithmic Strategy for the Evaluation and Management of Type B Dissections

An experience- and data-based approach to this challenging and diverse thoracic pathology.

BY MICHAEL D. DAKE, MD

Around 20 years ago, when I was about 7 years out of my fellowship training, I was sent the films of a 55-year-old man with an uncomplicated type B dissection. I saw the patient in clinic, and, as per the standard at the time, I recommended that the referring physician treat this patient with medical management. Two years later, during a weekend when I was on call, I was notified that a patient in shock with a ruptured aneurysm was being transferred by air ambulance. When the patient arrived, I was shocked to see my previous consult patient. How could this happen in just 2 years? Had I done something wrong?

EXPANDING TEVAR INDICATIONS

Determining the best method of treatment for individual patients with type B aortic dissections has always presented a vexing challenge for physicians. Physicians are often faced with balancing the conservative approach of medical management with the more aggressive approaches of surgical or endovascular treatments. With the high surgical mortality rate for patients presenting with acute complicated type B dissections, physicians have readily adopted thoracic endovascular aortic repair (TEVAR) as the accepted therapy for this condition.

With better TEVAR devices achieving US Food and Drug Administration approval of a broad indication for the treatment of all type B dissections and new insights regarding physiological predictors of future complications, physicians have expanded their consideration of TEVAR to treat the multiple challenges of this etiology. In this regard, based on their performance in the study of acute complicated

type B dissections, both Gore & Associates and Medtronic, Inc. were granted a US Food and Drug Administration indication to treat all type B dissections with their devices. The broad treatment indication was given to balance pre-market and postmarket studies and more quickly provide on-label alternatives to physicians and their patients. This allows physicians to treat all type B dissections while continued data are being collected by the Vascular Quality Initiative using a collaborative, multicompartment-sponsored postapproval study.¹

INITIAL PATIENT ASSESSMENT

When considering a complex variety of relevant factors, such as the patient's condition and various physiological predictors, an algorithmic approach may prove useful in deciding among treatment options. In essence, an algorithm is meant to provide a simplified, streamlined guide to decision making when numerous input considerations exist. A useful algorithm should help discriminate between choices on a high level and prioritize the relevance of various concerns while also providing the necessary detail for justifying every decision step. The algorithm in this article attempts just that, by providing a simple, linear structure that has depth to support each step. Additionally, the algorithm is stratified left to right and top-to-bottom to reflect the clinical urgency of treatment (Figure 1).

DISSECT

Starting in the top left corner, the evaluation begins with a patient assessment using a simple mnemonic of *DISSECT*. The mnemonic provides an easy-to-follow, step-

FIGURE 1. FULL ALGORITHM OVERVIEW



wise assessment of six clinical and anatomic characteristics of dissection deemed most relevant to treatment planning in the era of endovascular options. It was originally designed to facilitate communication among caregivers and colleagues of different backgrounds and at different points of care, including outside hospital personnel, transfer team members, EMT service providers, emergency department physicians, medical trainees, nursing staff, as well as attending and consulting physicians.

Beyond the traditional considerations of medical therapy and open surgical care, this mnemonic approach ensures that the key features of disease that determine the suitability and appropriateness of endovascular therapies are included in the initial evaluation and discussions of treatment alternatives. Late-night phone discussions among colleagues regarding a patient in transfer or presenting to the emergency department are facilitated by the routine presentation of the DISSECT sequence's individual dissection features that allow for confident analysis and triage.

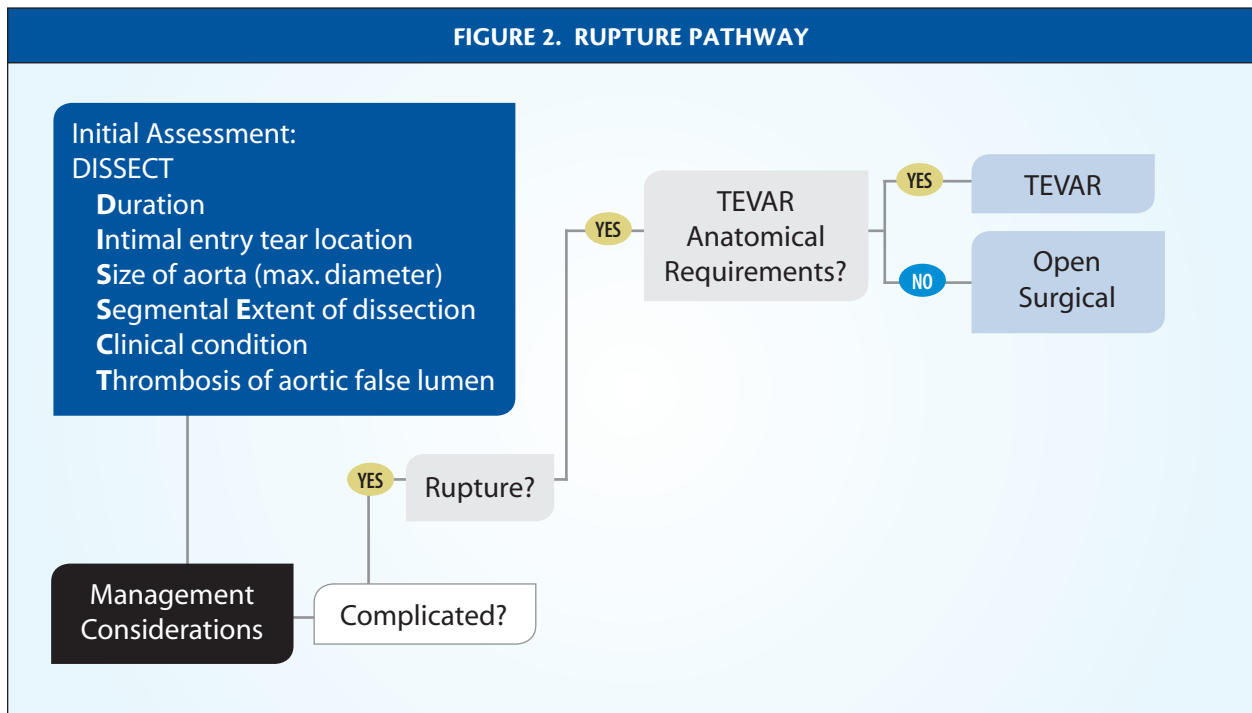
The publication, "DISSECT: a new mnemonic-based approach to the categorization of aortic dissection" describes the meaning of each letter in detail, but here is a quick summary.²

The "D" stands for the *duration* the patient has had the dissection. Traditionally, *acute* is used to classify the disease process in patients whose initial symptoms are 14 days or less in duration, whereas the term *chronic* dissection is applied to those with a dissection older than 14 days. These time designations were established in a 1958 article by Albert Hirst titled, "Dissecting aneurysm of the aorta: a review of 505 cases," in which Hirst notes gross anatomic morphological changes in the septum at approximately 14 days.³ However, instead of classifying duration into these general categories, the field is moving toward a more precise definition of the duration of a dissection to help better understand the patient's true morphological disease state and the potential responses to the newer range of therapeutic options.

The "I" in DISSECT describes the *intimal tear* or primary entry tear. Crucial information includes not only the exact location of the tear but also the location of the tear relative to the greater curve ("convexity") or inner curve ("concavity") of the aorta.

The first "S" is related to the *size* of the aorta, specifically the maximum diameter at any level in the dissected segment. This transaortic diameter is measured in an orthogo-

FIGURE 2. RUPTURE PATHWAY



nal plane to the aorta centerline display. This dimension may prove to be one of the simplest yet most important features of the initial assessment. The application of this variable within the algorithmic sequence is especially relevant upon initial presentation of patients with uncomplicated dissection when evaluating the risk of disease progression, as we will discuss later.

The “SE” portion of DISSECT stands for the *segment of extension*. As we know, aortic dissections occur in the medial layer of the vessel and can propagate distally well into the abdominal aorta and even down into the femoral arteries. They can also extend proximally from the primary entry tear to involve the aortic arch and ascending segment. Capturing information on the extent of dissection and affected visceral vessels is important in determining if an endovascular approach is feasible.

The letter “C” is used to capture the clinical *complications* of the dissection. It directs the physician to identify any of the clinically important complications of the disease that may mandate immediate intervention. Aortic rupture and clinically relevant branch vessel involvement are two classic examples of complications that dramatically influence early mortality. These high-risk features of disease warrant careful evaluation and prompt management to avoid potentially irreversible sequelae, including death. Extension of the dissection and rapid enlargement of the aortic false lumen (FL) are also findings that may merit expeditious intervention, but both of these possibilities require reimaging sub-

sequent to the initial diagnosis to establish a change in appearance.

Last, the “T” captures the extent of *thrombus formation* within the FL. In this regard, the status of any clot within the FL is an important predictor of disease progression. Partial thrombosis in conjunction with mural clot and a patent FL channel at any aortic level is associated with a higher risk of disease progression than with a patent FL, which has a worse prognosis than a completely thrombosed false channel.

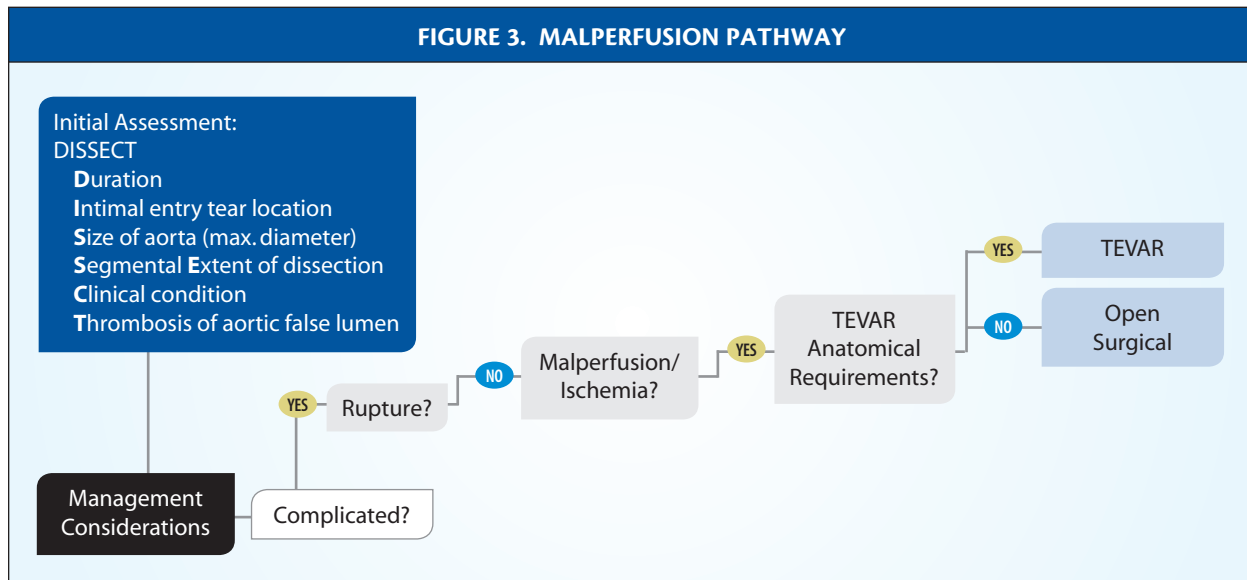
MANAGEMENT CONSIDERATIONS

Once the initial patient assessment is complete by following the “DISSECT” mnemonic approach, we move onto the *management considerations* portion of the algorithm. For simplicity, decision junctions in the algorithm are presented as binary yes-or-no questions.

Complications

The answer to the first and primary question, “Is the patient presenting with a complication?” is captured in the “C” portion of the mnemonic analysis. Although the definition of “complicated” varies in the literature, we focus on whether the patient is presenting with a rupture or visceral malperfusion, including spinal cord ischemia, which are consensually agreed-upon complications. Because rupture is the most severe of all the complications in aortic dissection and requires immediate treatment, it is appropriately located at the top of the algorithm (Figure 2). If the patient

FIGURE 3. MALPERFUSION PATHWAY



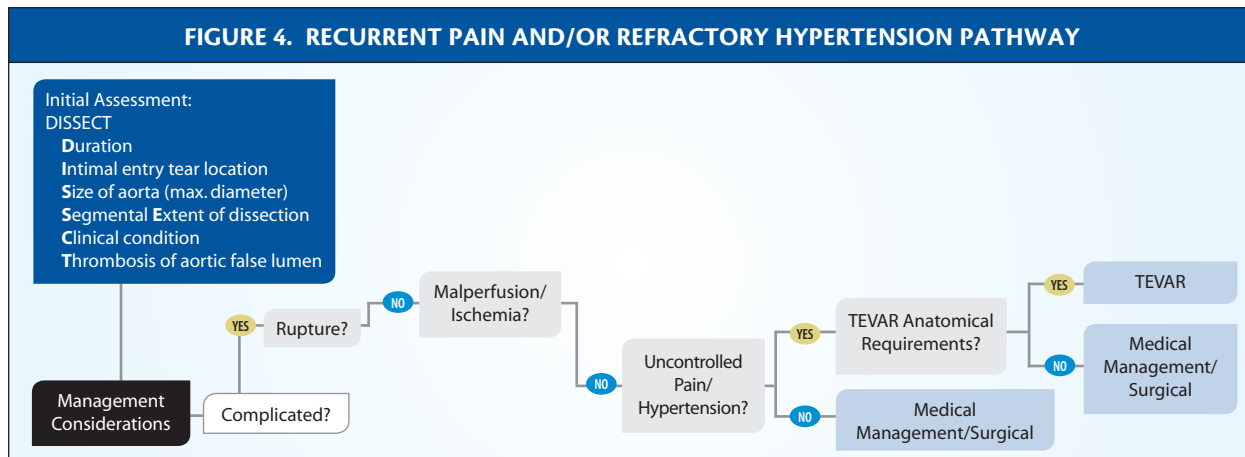
is experiencing rupture, the next piece of information needed in considering treatment options is whether the aortic anatomy meets TEVAR anatomical requirements, which vary according to endovascular device indication and may be discerned from respective instructions for use.

The goal for TEVAR treatment of a rupture that complicates aortic dissection is to completely cover the primary entry tear and depressurize the FL. This should initiate progressive thrombosis over the length of the aortic segment covered by the endograft. Rupture sites in the FL wall are often difficult to identify but are typically found directly opposite to the initial entry tear site.

When treating ruptures, multiple devices are typically needed to ensure a long length of coverage, usually to the level of the diaphragm or immediately suprarenal, to prevent potential retrograde flow in the FL through distal tears. If using multiple devices, the order of placement is critical. The most proximal device should be placed first over the initial tear site, with subsequent delivery of same-sized devices placed distally. Paraparesis or paraplegia is always a relevant risk to consider when covering a long segment of the thoracic aorta (≥ 20 cm), but the literature detailing this approach reports low percentages of debilitating long-term effects.⁴ If patients experience motor or sensory neurological symptoms after TEVAR, rapid initiation of a protocol to treat spinal cord ischemia (including placement of a lumbar catheter for cerebrospinal fluid drainage, ensuring a mean blood pressure of ≥ 80 to 90 mm Hg and a normal hematocrit, etc.) frequently results in successful symptom reversal.

Clinically relevant branch vessel malperfusion is a similarly dangerous complication and is the next consideration after rupture in the algorithm (Figure 3). Up to 30% of patients with dissection exhibit some level of malperfusion or ischemia.^{5,6} Malperfusion may be evidenced by the patient exhibiting symptoms, blood chemistry abnormalities, and/or hemodynamic or physiological deficits. In addition, appropriate corresponding imaging findings, typically

FIGURE 4. RECURRENT PAIN AND/OR REFRACTORY HYPERTENSION PATHWAY



identified on CT angiography, are a necessary association that must be appreciated to diagnose clinically relevant branch compromise.

Anatomical Requirements

Like rupture, the patient should meet anatomical requirements as a prerequisite to determining if TEVAR is appropriate. Although the procedural goals for treating malperfusion or ischemic events are similar to the treatment of rupture, a step-by-step treatment approach is typically preferred. In this regard, an aortic endograft is first placed over the primary entry tear site. However, the malperfusion may not adequately be corrected in the affected branch artery/arteries with a single device. In this case, careful evaluation of the flow within the aortic lumens, as well as the involved branch/branches after endograft placement, is required before undertaking further intervention. Remember, just because an endograft is placed remotely in the proximal descending aorta to cover the site of the primary intimal tear, occlusive lesions within involved branch vessels may remain critically compromised and may require an interventional procedure within the affected artery. No literature references for ruptures (or malperfusion) are provided in the algorithm, as their treatment with TEVAR have been widely studied and agreed upon.

Medical Management

In continuing to follow the algorithm along the next possible path, we address patients who have recurrent pain or difficulty managing their hypertension as possible candidates for intervention beyond medical management (Figure 4). Trimarchi et al retrospectively studied patients from the International Registry of Aortic Dissection who exhibited recurrent and/or refractory pain or uncontrollable hypertension.⁷ They found that even with patients receiving medical management, those experiencing recurrent and/or refractory pain or hypertension had a significantly higher in-hospital mortality rate of 35.6% ($P = .0003$)

when compared with those who presented without clinical complications (mortality rate of 1.5%). Most of the deaths were attributed to aortic rupture. They concluded that patients with refractory pain and/or refractory hypertension were at increased risk of disease progression and may be suitable for “aortic intervention, such as via an endovascular approach.”

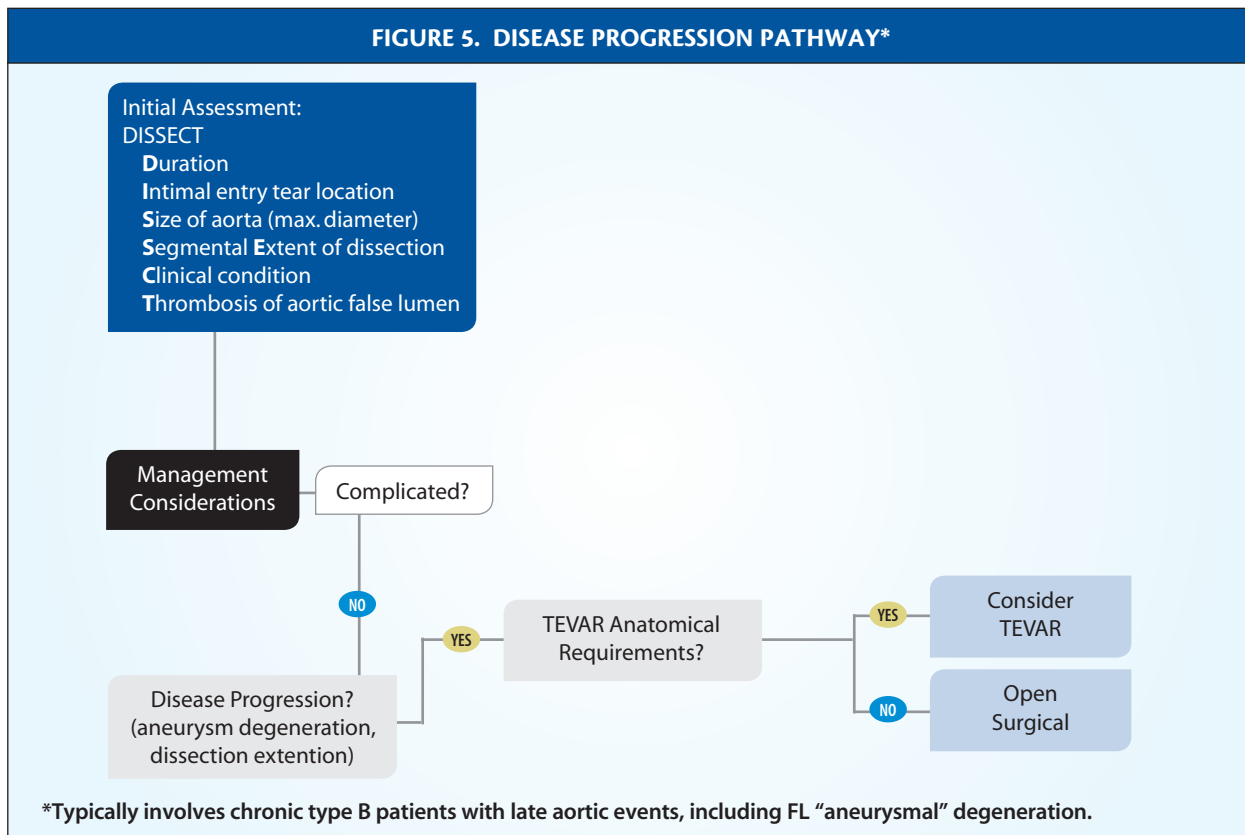
Disease Progression

If the patient is not experiencing any of the previously mentioned complications, attention is directed to the bottom portion of the algorithm (Figure 5). Here, the first question asks, “Is there disease progression?” *Disease progression* is a generic term in this algorithm that denotes FL degeneration that becomes “aneurysmal” or extension of the FL that could cause malperfusion or ischemic events. Although this consideration may span the classic boundaries between acute (≤ 14 days from symptom onset) and chronic dissection (> 14 days), it also includes a rapidly growing FL in the acute phase. Practically, however, the majority of disease progression events are late dilation or continued expansion of the FL. Occasionally, new septal tears or poor hypertension management can propagate the dissection proximally or distally, causing new symptoms for the patient.

Up to 25% to 30% of patients require late aortic interventions for aneurysm expansion, extension of the progressive dissection, or other related complications.⁸ One literature reference proposing a rapid growth metric is included in the algorithm, as there is no real consensus on what rapid growth entails. Akin et al describe abnormal FL enlargement in the chronic phase as expansion of any portion of the FL by 1 cm from diagnosis to the 1-year follow-up or enlargement that contributes to an overall aortic diameter (TL + FL) of 5.5 cm.⁹

In the acute setting, most authorities agree that FL enlargement of ≥ 5 mm at 30 days from the initial diagno-

FIGURE 5. DISEASE PROGRESSION PATHWAY*



sis represents rapid growth. Consequently, if these patients do not warrant immediate intervention, they require close follow-up, with imaging surveillance at frequent intervals to diagnose any progressive expansion.

As centers continue to have success, more chronic type B dissections with aneurysm degeneration are being treated with TEVAR as an alternative to open surgery. In these cases, TEVAR should be considered if the patient meets the anatomical requirements of a good landing zone and adequate access. Although the method of building from the proximal landing zone and extending aortic coverage with a same-sized device distally is performed with acute dissections, different techniques have been used when treating chronic dissections. The goal of covering the primary entry tear and depressurizing the FL remains the same; however, there is typically a thick aortic septum in chronic dissections, and remodeling of the true lumen may become a challenge. The anatomical TEVAR requirements are the same as for the other dissection categories, but case planning widely differs depending on center experience and even by country.

Delaying Treatment

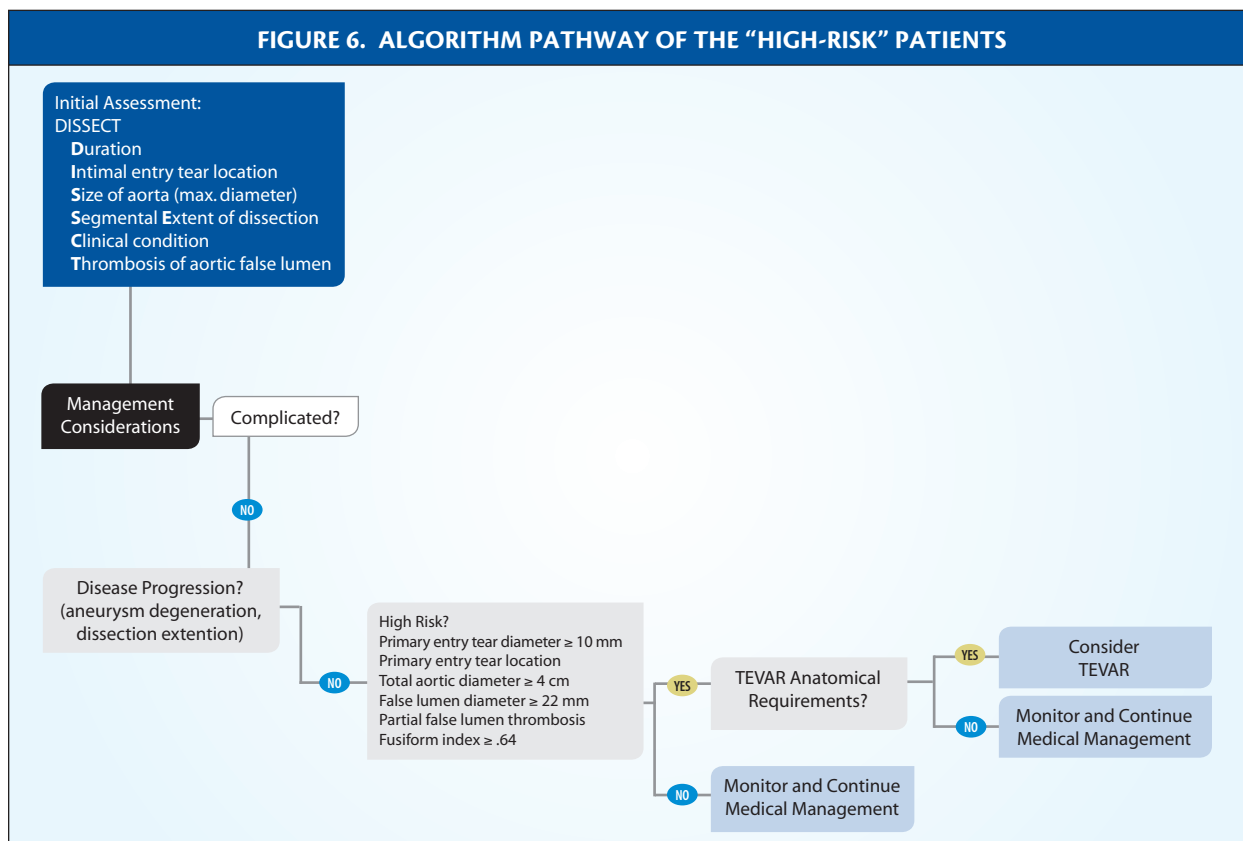
One arguable advantage of treatment at a later time period is that the septum and aorta have had time to

“heal” in the chronic phase. With the aorta less vulnerable to intraoperative mishaps, other approaches have been established. Many centers report building coverage with multiple devices, distal to proximal. The advantage of this approach is that a smaller device diameter may be placed distally in a relatively noncompliant, smaller-diameter true lumen. The smaller-diameter device is placed first with the larger, more proximal endograft extending to the proximal landing zone to close the intimal tear site in the setting of classic dissection anatomy. In an acute dissection, this is not a viable strategy due to the risk of influencing flow through the entry tear, which may risk propagating the dissection proximally and into the transverse arch or ascending aorta. With this in mind, it should be noted that in the absence of significant diameter mismatches between the proximal and more distal true lumen, the preferred sequence for device implantation when treating chronic aortic dissection with FL aneurysm is the more routine top-to-bottom placement when more than one device is required.

Identifying High-Risk Patients

If no disease progression is noted, the bottom-most and last path to *high risk* should be navigated (Figure 6). At present, one of the most interesting debates among cardiovascular specialists concerns the endovascular treatment

FIGURE 6. ALGORITHM PATHWAY OF THE “HIGH-RISK” PATIENTS



of patients presenting with uncomplicated type B dissections. Published data from the INSTEAD, INSTEAD-XL, and ADSORB trials have fueled the current opinionated discussions and led all interested parties to ponder the real meaning of uncomplicated dissection.¹⁰⁻¹² Specifically, debate revolves around the emerging concept that the prognosis of an initially uncomplicated dissection at the time of diagnosis is highly variable, with many cases progressing in the first 2 to 5 years.

Traditionally, patients who are asymptomatic and have “stable aortic dissections” are managed with a medical therapy regimen and are regularly monitored with imaging. As previously noted, 25% to 30% of these patients will experience some level of disease progression. Identifying these high-risk patients has proven to be a challenge. With the new broad approvals of TEVAR devices, physicians have become increasingly open to the idea of using these devices to proactively treat the future “bad actors” or high-risk patients.

Many attempts to simply identify these bad actors by applying a single prognostic metric have been less than successful, and consequently, none of these predictors has been widely adopted. A profile based on a multifactorial composite analysis, however, may provide a more powerful predictor based on its potential to develop a preponder-

ance of evidence that allows identification of high-risk patients with multiple positive features that correlate with progression. Most of these predictors have come from published experiences in Japan. The algorithm provides a framework to analyze high-risk factors and proposes treatment in this group of “high-risk” uncomplicated patients at an optimal time to increase the odds of full aortic remodeling while minimizing intraprocedural risks and potential future problems.

Timing for treating high-risk uncomplicated type B dissection patients is being actively investigated in many centers.¹³ Some patients may benefit from delaying TEVAR treatment to establish control of hypertension and to allow the septum to go through an initial “seasoning” process. The rationale is that this delay will enable a safer procedure with a lower risk of dissection progression events, including retrograde type A extension, and allow collateral development to perhaps lower the risk of spinal ischemic events.

Predicting Degeneration

The algorithm identifies six of the most prominent ideas around identifying these high-risk patients. The first two characterize the primary entry tear, focusing on whether its initial size is > 10 mm and its location in the aorta. If a large entry tear (≥ 10 mm) exists at initial presentation, fur-

ther FL growth is likely.^{11,14} Along with the size of the tear, Loewe et al and Weiss et al found that the location of the tear affects the risk of future events; namely, tear location on the inner curve (“concavity”) may characterize dissections that are more susceptible to retrograde dissection into the transverse and/or ascending aorta.^{15,16}

The next predictor recognizes the importance of the initial total aortic diameter or transaortic diameter, which has been described in multiple peer-reviewed articles. Most publications detail initial total diameters of 40 mm or greater as prognostic of aneurysmal degeneration of the FL.¹⁷⁻²⁰

Potentially, one of the most useful predictors for identifying patients at risk for aneurysmal degeneration was developed by Song et al from Korea.²¹ Their technique is to measure the aortic FL at initial presentation. This simple metric is obtained by measuring from the outer wall of the FL perpendicular to the septum. They found that a perpendicular measurement of 22 mm or greater predicted late-phase growth of the FL.

A more common predictor of long-term progression is the characterization of thrombus within the FL, which was briefly discussed earlier. Although one would assume that a fully patent FL would lead to FL dilatation, partial FL thrombosis was shown to lead to higher patient mortality.^{22,23} The plausible theory is that partial thrombosis in the distal FL blocks potential exit or runoff flow, creating back pressure on the proximal FL. Fully patent FLs or thrombosed FLs are associated with lower rates of aortic FL dilation.

The last indicator for late aortic events is based on a recurrent idea to compare the true lumen diameter to the total aortic lumen diameter in the form of a ratio. One such ratio is called the Marui Fusiform Index.²⁴ Developed by Marui et al, it measures the maximum total diameter (including the FL) of the descending aorta and divides this term by the summation of diameter of the aortic arch and the transaortic diameter of the descending aorta at the level of the pulmonary artery. A ratio > 0.64 is associated with higher patient risk.

SUMMARY

By identifying and proactively using TEVAR to treat high-risk uncomplicated patients, we may be able to promote more comprehensive positive aortic remodeling and minimize or eliminate the need for late aortic interventions. However, in the absence of complications or reliable predictors, traditional approaches of medical management and close clinical and imaging surveillance should be continued.

As new information becomes available through multicenter experience and postapproval studies, a more defini-

tive decision tree will emerge. Technology will continue to evolve with better devices and better techniques, and less-invasive approaches will continue to open up new treatment opportunities and better outcomes for physicians and their patients. ■

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