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# Latest Concepts in Diagnosis and Management of Coronary Thrombus

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## ABSTRACT

Coronary thrombus is an integral part of unstable atherosclerotic plaque causing acute coronary syndrome. The thrombus results from a either a disrupted atherosclerotic plaque or plaque erosion. A vulnerable plaque initiates the formation of a thrombus which consists of platelets, red blood cells, vasoconstrictors, and procoagulant bound by fibrin fibers. intracoronary thrombi (ICT) can be red or white. Angiography is the gold standard for diagnosis of coronary thrombus. Thrombus burden inversely impacts myocardial perfusion, with high thrombus burden resulting in sub optimal primary percutaneous coronary intervention (PCI) results and poor outcome. Management of ICT is a therapeutic challenge and involves a combination of pharmacological and mechanical therapies. Low thrombus burden is dealt with standard pharmacotherapy, balloon angioplasty, and stenting with occasional need to use aspiration catheter. High thrombus burden requires a targeted thrombus strategy.

**Keywords:** Intracoronary thrombus, Plaque, Thrombolysis, Vulnerable plaque, Angiography

## INTRODUCTION

Coronary thrombus is an integral part of unstable atherosclerotic plaque causing acute coronary syndrome. Intracoronary thrombi (ICT) result in life-threatening acute myocardial infarction, but may also remain silent forming healed lesions that contribute to plaque progression and luminal narrowing. They are responsible for nearly one-third of the cases of sudden cardiac death.

## PATHOGENESIS OF CORONARY THROMBUS

In majority, the thrombus results from a disrupted atherosclerotic plaque and in others superimposed on plaque erosion [Figure 1].[1]

A vulnerable plaque[2] initiates the formation of a thrombus which consists of platelets, red blood cells, vasoconstrictors, and procoagulant bound by fibrin fibers. A vulnerable plaque is one with a soft lipid rich necrotic core which makes up >30% of the plaque and a thin <65 μm fibrous cap.

## MORPHOLOGY OF CORONARY THROMBUS

The structure and physical characteristics of a thrombus are essential to determine the best treatment options. ICT can be red or white [Figure 2] according to pathological and imaging studies.[3]

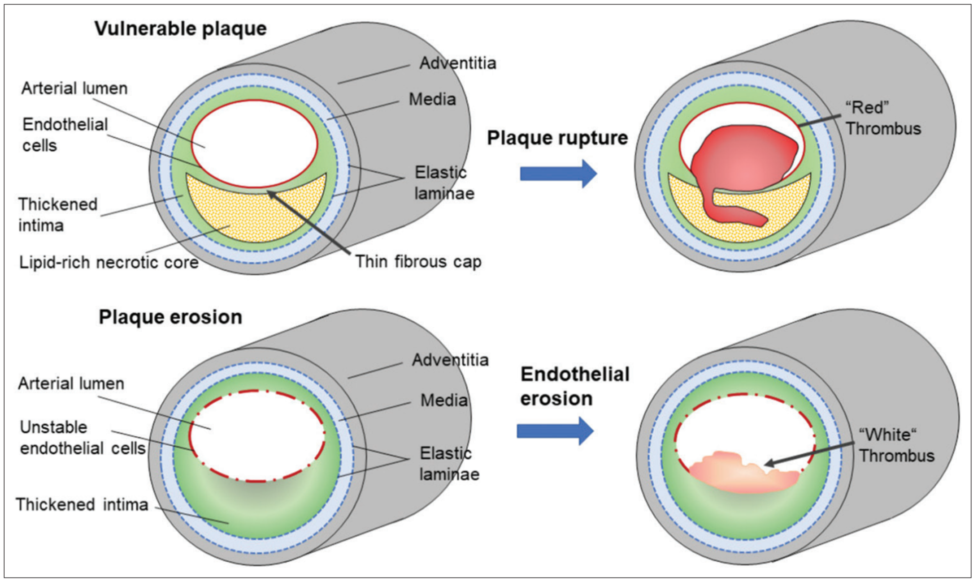


**Figure 1:** Vulnerable plaque and plaque erosion causing thrombus.

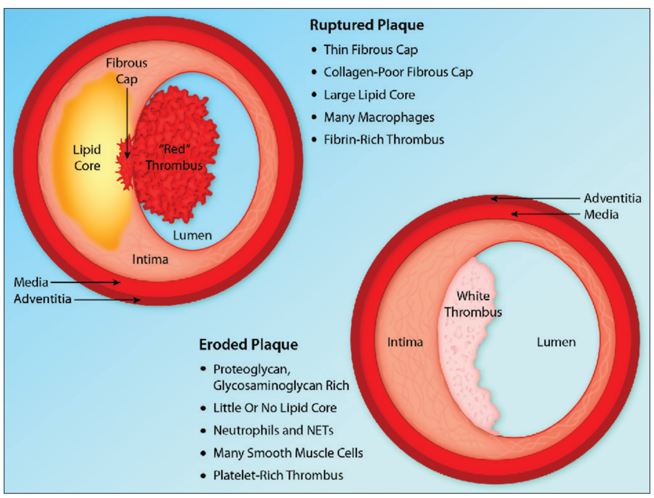


**Figure 2:** Red and white thrombus (Morphology).

In the process of thrombi formation, white thrombi appear first due to platelet aggregation and adherence to the damaged endothelium. This results in diminished blood flow, followed by venous type/stagnation type red thrombi due to fibrin deposition and red blood cells entanglement [Figure 3 and Table 1].

Thus white thrombi are expected to be present with shorter ischemic time than red thrombi. According to a study by Silvain *et al.*,[4] there is a 2-fold increase in fibrin content in the thrombus per ischemic hour (48.4% fibrin at <3 h of symptoms onset to 66.9% at >6 h); while platelet content decreased from 24.9% to 9.1%. Similarly Yang *et al.*[5] reported a 1.4-fold increase in the incidence of red thrombus in STEMI per ischemic hour.

**Table 1:** Differences between red and white thrombus.

| White thrombus | Red thrombus |
|---|---|
| Platelet rich; formed by adherence of platelets to abnormal/damaged endothelium | Mainly composed of erythrocyte and fibrin |
| Major cause is plaque rupture | Results from blood stasis and hypercoagulability |
| Seen in high pressure arteries | Seen in low pressure veins |
| Seen in atheromatous blood vessels | Seen in normal blood vessels |

Traditional teaching is that thrombi is red in STEMI while white in NSTEMI, hence fibrinolytic therapy in useful in the first one but not in the later. Recent studies have shown that two-thirds of thrombi in STEMI are red while one-third is white. Red thrombus is more common in smokers, is associated with higher thrombus burden, more distal embolization and no-reflow and higher in-hospital major adverse cardiac events.[6] In the early stages the clot is soft and friable and amenable to treatment with fibrinolysis or revascularization. As thrombus ages with delayed presentation, dense and thin fibrin predominates which is resistant to treatment.

## IMAGING MODALITIES TO DIAGONIZE THROMBUS

### Angiography

Gold standard for diagnosis of acute coronary thrombus. Four characteristics features are highly specific (92–100%) for intracoronary thrombus[5,6] [Figure 4].

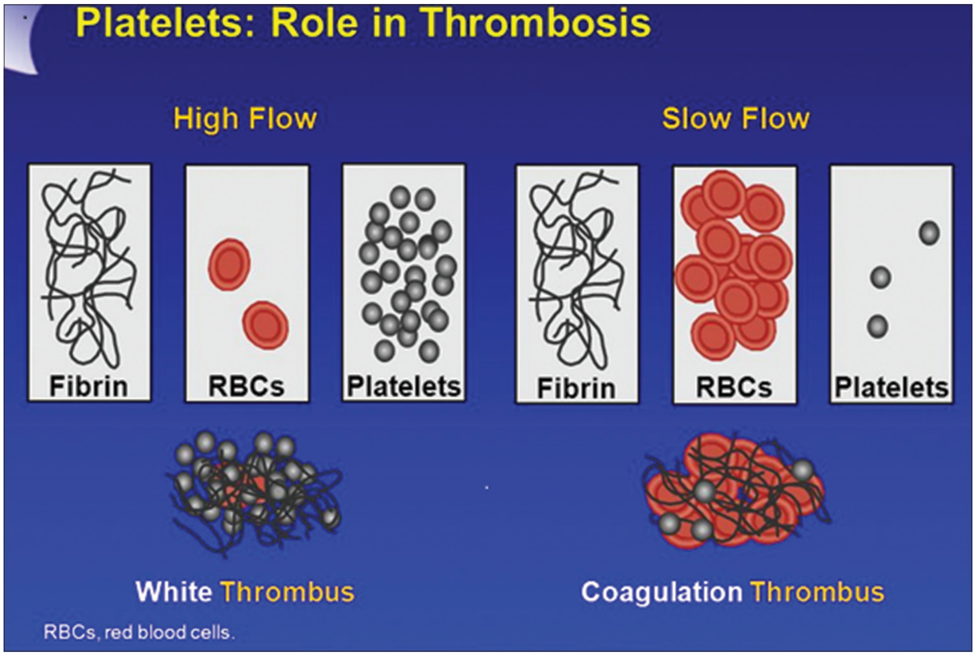


**Figure 3:** Process of red and white thrombus formation.

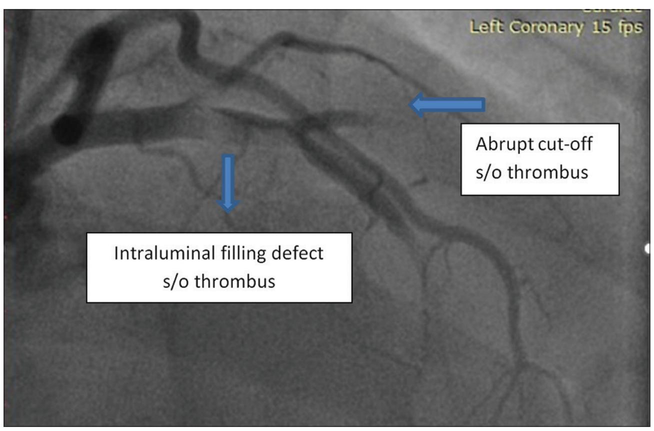


**Figure 4:** Angiography of the left system showing thrombus in left anterior descending artery (LAD) and D1,2.

1. Spherical, ovoid, or irregular filling defect
2. Abrupt vessel cutoff
3. Intraluminal staining
4. Coronary filling defect.

Irregular filling defect with intraluminal staining has highest specificities (99–100%) but low sensitivity (≤55%) for the presence of a thrombotic lesion. Rehr *et al.*[7] defined intracoronary thrombus as presence of abrupt vessel cutoff with contrast persistence and intraluminal filling defect [Table 2].

Siano's restratification of Grade 5. This grading consists of re-stratification of TIMI Grade 5 thrombus following guide wire crossing of the thrombus and enables decision for further coronary interventions. Their method utilizes either a guide wire or a 1.5 mm balloon for crossing and recanalization of the target thrombus. This intervention re-establishes a certain degree of antegrade coronary flow to the extent that the exposed underlying thrombus can undergo restratification into either a small thrombus burden [Grade 1–3] or a large thrombus burden [Grade 4] with treatment ensuing accordingly.

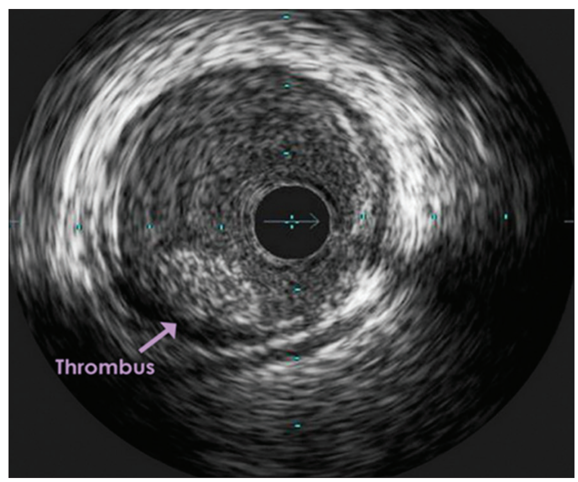


**Figure 5:** Intravascular ultrasound image of thrombus hypo dense (40 Hounsfield units s/o thrombus).

Yip *et al.*[8] angiographic criteria for high thrombus burden [Table 3].

## Angioscopy

Intracoronary angioscopy is an endoscopic technique for direct visualization of the coronary artery lumen. Thrombi on

**Table 2:** TIMI thrombus grading.

| TIMI thrombus grading | |
|---|---|
| Grade 0 | No angiographic evidence of thrombus |
| Grade 1 Possible thrombus | Reduced contrast density, haziness, irregular lesion contour, or a smooth convex meniscus at the site of total occlusion suggestive but not diagnostic of thrombus |
| Grade 2 Small thrombus | Definite thrombus, with greatest dimensions <1/2 the vessel diameter |
| Grade 3 Moderate thrombus | Definite thrombus but with greatest linear dimension >1/2 but <2 vessel diameters |
| Grade 4 Large thrombus | Definite thrombus, with the largest linear dimension >2 vessel diameters |
| Grade 5 | Total occlusion |

Grade 1–3: Low thrombus burden
Grade 4–5: High thrombus burden

**Table 3:** Yip *et al*. criteria.

| Estimated diameter of IRA *lumen* of at least 4.0 mm |
|---|
| Linear thrombus with linear dimension three-fold greater than diameter |
| Cut-off occlusion |
| Thrombus accumulation on the proximal occlusion (>5.0 mm) |
| Thrombus floating on proximal end |
| Sustained dye stasis on distal obstruction. |

angioscopy is defined as masses (red and/or white) adherent to the intima with luminal protrusion which may undulate during infusion of clear viewing solution.[9]

### *Advantage*

1. Histologic appearance of the thrombus can be assessed
2. Can distinguish it from the vessel wall even if the clot is very small.[10]

### *Disadvantage*

1. Angioscope cannot be passed through the obstructed lesion, hence portion of the vessel distal to it cannot be examined. Thrombus downstream can be missed on percutaneous angioscopy but not on retrograde angioscopy performed during bypass surgery[11]
2. Not readily available.

## Intravascular ultrasound (IVUS)

Thrombus is identified as echo lucent intraluminal mass often with a layered or pedunculated appearance [Figure 5]. Acute thrombus-appears bright with sharp delineation and no signal attenuation.[12]

1. Subacute thrombus - Light to dark grey appearance with white speckles and less clear delineation
2. Organized thrombus - Homogeneous dark appearance starting from lumen wall with sharp delineation and may have mild signal attenuation
3. Protruding thrombus appears as lobulated light to dark grey appearance protruding into the lumen
4. Recanalized thrombus - Multiple cavities filled with blood speckles.

## Optical coherence tomography (OCT)

OCT is a high-resolution intravascular imaging technique with excellent contrast between the vessel lumen and intravascular structures.[13] It is more sensitive (90–96%) than IVUS for detection of intracoronary thrombus.

Thrombi are identified as masses protruding into the vessel lumen discontinuous from the surface of the vessel wall. Fresh thrombi are bright while old organized thrombi have dark ultrasonic appearance [Figure 6].

- OCT can differentiate between the types of thrombi which has been confirmed by histology.[13,14]
    - Red thrombi appear high-backscattering with a signal-free shadowing
    - White thrombus appears low-backscattering
    - Thrombus can be graded on a 6-point scale, where 1 represents purely white thrombus and 6 is purely red thrombus, creating thrombus attenuation score
    - Thrombus is considered white or mostly white, when the abluminal border of the thrombus or the vessel wall behind is seen. More the shadowing and poor visibility of the structures behind it, the redder the thrombus is scored.
- Recanalized thrombi [Figure 7] appear as signal rich, high back-scattered septa dividing lumen into multiple small cavities communicating with each other [Table 4] giving the Swiss cheese or honey-coomb appearance.

## Computed tomography angiography (CTA)

CT coronary angiography can detect intracoronary thrombus in good concordance with angiography and can be considered as the latest alternative to repeat coronary angiogram in high thrombus burden lesions.[15] Acute thrombus appears as low-density filling defect in the coronaries.

## Cardiac magnetic resonance (MR) imaging

Non-contrast-enhanced MR for direct thrombus imaging (MRDTI) can selectively visualize intracoronary thrombus. MRDTI is performed with a T1-weighted, 3-dimensional, inversion-recovery black-blood gradient-echo sequence without contrast administration. The contrast-to-noise ratio (CNR) is greater in coronary segments containing

**Table 4:** Thrombus grading on OCT.

| | |
|---|---|
| *Prati's TS* | *TS* - Sum of each cross-section score, obtained by measuring the number of involved quadrants encroached by thrombus during a pullback<br>- TS 0: absent thrombus<br>- TS 1 2 3 or 4 (subtending 1, 2, 3 or 4 quadrant) |
| *Magro criteria*<br>To measure in-stent TA<br>Pre-stenting evaluation of thrombus | *In-stent TA*=Stent area−Lumen area+Free *TA*+incomplete strut apposition<br>*TV*=Mean TA×length of stented segment within which thrombus material was deemed present at the OCT long-axis reconstruction<br>Atherothrombotic burden=Ratio between TV and stent volume<br>Values above the median is considered as high thrombus burden |

OCT: Optical coherence tomography, TS: Thrombus score, TA: Thrombus area, TV: Thrombus volume

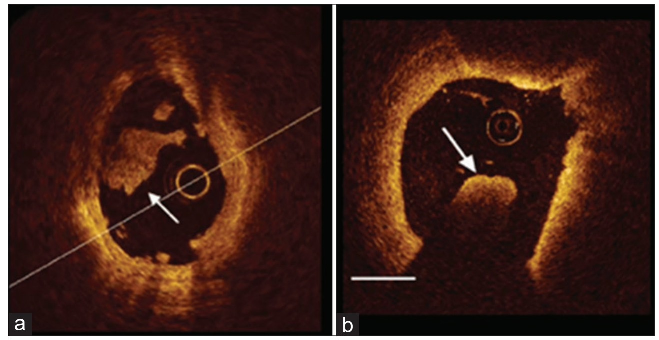


**Figure 6:** Thrombus On Oct. (a) White thrombus (platelet rich, exhibits low signal attenuation) (b) Red thrombus (marked Signal attenuation).

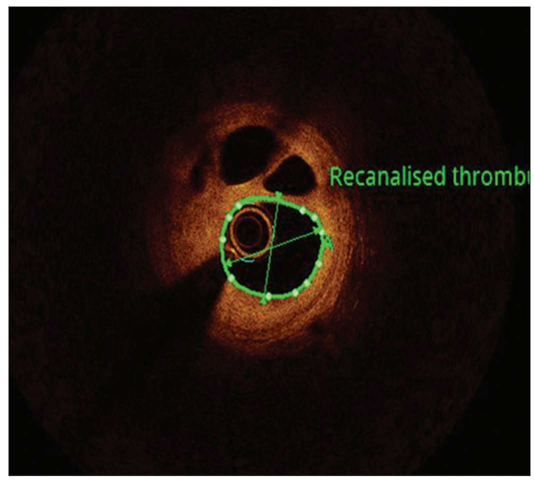

**Figure 7:** Recanalized thrombus on optical coherence tomography.

thrombus average about >15.[16] CNR >40 is 100% specific for intracoronary thrombus. Hyperintense plaque (HIP) on T1W1 images in patients with angina correlated to presence of intracoronary thrombus on OCT. HIP is defined as a PMR > 1.0, that is, signal intensity of coronary plaque divided by signal intensity of LV muscle near the coronary plaque. HIP is due to methaemoglobin in early stages of thrombus; RBC containing methaemoglobin cause shortening of T1.[17,18]

## MANAGEMENT OF INTRACORONARY THROMBUS

Intracoronary thrombus dissolution requires a disciplined approach which includes inhibition of the coagulation cascade and restoration of coronary flow. While the first is achieved with pharmacotherapy, the later with mechanical techniques including thrombus extraction devices. Low thrombus burden is dealt with standard pharmacotherapy, balloon angioplasty and stenting with occasional need to use aspiration catheter. High thrombus burden requires a targeted thrombus strategy.

### Pharmacotherapy

#### *Aspirin and P2Y12 antagonists*

A loading dose of aspirin (300 mg) and a P2Y12 antagonist (Clopidogrel 300–600 mg, Prasugrel 60 mg or Ticagrelor 180 mg) is mandatory in all cases of ACS especially STEMI. Early administration of these agents produces a significant reduction in thrombus burden even before initiation of any intervention. Cangrelor, a rapid onset intravenous P2Y12 antagonists, is also available for bridge therapy and for those requiring parenteral administration.

#### *Anticoagulation*

Peri-procedural anticoagulation can be achieved using unfractionated heparin or low-molecular weight heparin (enoxaparin) or factor Xa inhibition (fondaparinux) or reversible direct thrombin inhibitor (bivalirudin). Most catheterization lab use dose adjusted heparin (70–100 international units/kg) to maintain an activated coagulation time (ACT) of >300 s. In high thrombus burden cases, it is recommended to check ACT at repeated intervals with top-up heparin if required to maintain optimal anticoagulation. Heparin reduces fibrin formation and abolishes platelet contractile forces. Fondaparinux should not be used by itself in cardiac cath due to risk of coronary thrombus formation.

#### *Glycoprotein IIb/IIIa inhibitors*

Inhibit platelet aggregation and are recommended in cases of high thrombus burden to reduce no-reflow. These agents not only reduce the platelet aggregate size, but also improve the access of thrombolytic into the platelet-rich clot and thus improve their efficiency.

### *Intracoronary thrombolysis*

Useful in selective cases. In the DISSOLUTION trial;[19] upfront thrombolysis (intracoronary thrombolytic delivered through microcatheter in addition to aspiration thrombectomy) had higher TIMI flow and myocardial blush grade.

Limitation: Pharmacological intervention is less effective in already formed thrombus such as saphenous venous graft (SVG) graft with large thrombotic burden.[20]

## Thrombectomy

Mechanical thrombus removal/dissolution devices include the 1: Simple Manual Thrombus aspiration catheter or 2 complex mechanical devices which are power sourced (Rheolytic thrombectomy [RT], excimer laser [EL] thrombectomy, and the X-Sizer thrombectomy device) or ultrasonic sonication.

### *Manual thrombectomy*

Manual thrombectomy using thrombus aspiration catheter is the preferred mode of thrombus removal due to its simplicity and ease. Manual aspiration catheters are 4–6F in size and consist of an extraction lumen and aspiration syringe. Most are user friendly due to their low crossing profile, hydrophilic coating, flexible, and tapered tips.

[Table 5] A meta-analysis of these three trials TAPAS, TASTE, and TOTAL including 19047 patients, concluded that there is no difference in clinical outcomes with routine thrombectomy. Subgroup analysis showed fever cardiovascular deaths in high thrombus burden at the cost of an increased stroke rate.

**Table 5:** Clinical trials in routine manual thrombectomy.

| Clinical trials | Conclusion |
|---|---|
| TAPAS (Thrombus aspiration during percutaneous coronary intervention in acute myocardial infarction study), 2008. | Manual thrombus aspiration performed in STEMI, irrespective of their clinical and angiographic features (e.g., a visible thrombus on angiography) results in improved myocardial reperfusion and clinical outcome as compared with conventional PCI |
| TASTE (Thrombus Aspiration in ST-Elevation Myocardial Infarction in Scandinavia), 2013 | Routine thrombus aspiration before PCI as compared with PCI alone did not reduce 30-day mortality among patients with STEMI |
| TOTAL (Trial of Routine Aspiration Thrombectomy With PCI vs. PCI Alone in Patients With STEMI), 2015 | During primary PCI for STEMI, routine manual thrombectomy, as compared with PCI alone, did not reduce the risk of cardiovascular death, recurrent myocardial infarction, cardiogenic shock, or NYHA Class IV heart failure within 180 days but was associated with an increased rate of stroke within 30 days |

PCI: Percutaneous coronary intervention

Routine aspiration thrombectomy is Class III as per ACC/AHA guidelines. Even though the routine thrombus aspiration during primary percutaneous coronary intervention (PPCI) does not provide clinical benefit in terms of cardiovascular death, recurrent myocardial infarction, and heart failure; it may be beneficial in selective cases of acute myocardial infarction with high thrombus burden, and a few cases where thrombus develops post PCI and stent deployment.[20]

Limitations of aspiration catheters:

1. Aspiration catheters are difficulty to deliver in tortuous vessels
2. Less effective for aspiration in distal segments
3. Risk of dissection/perforation
4. Limited yield in high thrombus burden owing to low aspiration pressure and small evacuation holes. Catheter induced distal embolization
5. Effective thrombus removal in <50% cases

Further studies have suggested that periprocedural stroke can be preventable by prudent procedure or appropriate periprocedural management. To ensure effective thrombus removal and reduce the risk of stroke, the following steps during the procedure are advised:

- Guiding catheter should be well engaged
- Start aspiration in the guiding catheter
- Make multiple passes till syringe is full, switch syringes if needed
- Ensure that a new syringe is placed with full negative pressure is attached to the aspiration catheter at time of removal
- Before removal of the aspiration catheter, a small contrast test injection is advised to check that the guide is engaged
- Back bleed the guide catheter or aspirate through side port of manifold after removal of the aspiration catheter to ensure it is cleared of any clots before taking further angiographic images.

## Mechanical thrombectomy devices

Due to their larger bore and sustained suction are more efficient and faster reperfusion over manual aspiration.

### *Rheolytic thrombectomy (RT)*

The AngioJet RT device (Boston Scientific Corporation) fragments the thrombus with high speed saline jets which are then removed by passive aspiration into the catheter.

Venture effect creates a pressure gradient, where pressure in the catheter is less than the vessel, so macerated thrombus can be sucked into the catheter tip [Table 6].

**Table 6:** Present status of rheolytic thrombectomy with angiojet trials and complications

| Evidence | Complications |
|---|---|
| *AiMI trial*[21]<br>• No benefit in STEMI (no reduction in infarct size, TIMI flow, myocardial blush)<br>• higher rate of MACE<br>*JETSTENT trial*[22]<br>• Low MACE in high thrombus burden STEMI patients<br>• Primary efficacy endpoints not met.<br>*FAST trial*[23]<br>• Significant improvement in perfusion in AMI patients with extensive thrombus | 1. High risk of distal embolization<br>2. High rates of heart block and arrhythmias<br>• Possible due to vibration from the device (activation of mechanoreceptors and release of adenosine from lysed red blood cells) |

MACE: Major adverse cardiac events

***Fragmentation thrombectomy***

X-Sizer thrombectomy device (EndiCOR Medical Inc) causes fragmentation and removal of intracoronary thrombus. It is a double lumen over the wire system with a helical cutter at its distal tip. While one lumen is to advance over a 0.014 inch guidewire, the other catheter lumen is connected to a vacuum bottle (250 mL) where aspirated debris is collected. The cutter rotates at 2100 rpm driven by a hand-held battery motor unit. Activation of the system leads to fragmentation of the thrombus, which is aspirated by vacuum through the outer lumen. Available in two sizes 1.5 mm (7F compatible) and 2-mm (8F compatible).

The device prove safe, effective, easy to use, success rate of 87% with effective thrombus removal in 96% in the X-AMINE multicenter study.

***Mechanical aspiration thrombectomy***

The CAT Rx system (Penumbra, Inc.),[24] consists of a vacuum pump (Penumbra Engine pump) that can create a pure vacuum suction of 29 mm of Hg and a highly flexible and trackable aspiration catheter. The CAT Rx catheter is a laser-cut hypo tube inside a polymer-jacketed sleeve with multiple material transitions that make the catheter both atraumatic and trackable. It is rapid exchange system 6F compatible with an outer diameter of 1.75 mm.

In the multicenter CHEETAH[25] trial of 400 patients of ACS with high thrombus burden, the CAT Rx was found to be safe with no device-related strokes. Highly effective with final TIMI thrombus grade 0 achieved in 99.5%, TIMI 3 flow grade in 97.5%, and myocardial blush grade 3 in 99.75%. Rate of distal embolization was very low (0.75%).

The CAT Rx device is compatible with all coronary arteries. The device has been used off label successfully in bypass graft occlusion, to facilitate distal aspiration and deliver intracardiac pharmacologic agents through the aspiration lumen.

Though complications were less in the pilot study, complications anticipated are - stroke and systemic embolization; device induced dissection, shaft fracture, and inadvertent strut entry in acute stent thrombosis.

***Excimer laser thrombectomy (EL)***

EL is another proven adjunctive treatment modality to debulk intracoronary thrombus. EL are pulsed gas lasers that use a mixture of a rare gas and halogen as an active medium to generate pulses of short wavelength, high-energy ultraviolet (UV) light. Laser generated acoustic waves dissolve the fibrin fibers, suppress platelet aggregation, and vaporize the thrombus. The UV beam 308 nm used in EL alters kinetics of platelet aggregation resulting in stunned platelets with reduced platelet force. It is particularly effective in red thrombus and large thrombus where other modalities have proved in-effective. Spectranetics CVX-300 (Spectranetics, Colorado Springs, CO, USA) ELCA system is the only FDA approved laser emitting device. It consist of an EL generator [CVX 300] and pulsed xenon-chlorine laser catheters capable of delivering excimer energy (wavelength 308 nm and pulse length 185 ns) from 30 to 80 mJ/mm$^2$ (fluencies) at pulse repetition rates from 25 to 80 Hz. The catheters are available as concentric-type 0.9-, 1.4-, 1.7-, and 2.0-ELCA and eccentric-type 1.7- and 2.0 ECLA.

- Shishikura *et al*.[26] found EL to be superior to aspiration thrombectomy in acute MI with regards to trackability, higher TIMI 3 flow and the blush score 3. Low incidence of distal embolization, and in-hospital major adverse cardiac events including myocardial infarction, target lesion revascularization, coronary artery bypass graft, and death were noticed.
- CARMEL[27] study; ECLA proved to be beneficial in thrombus containing lesion in ACS with high TIMI flow and low rates of complications.
- Similar results were seen in the ULTRAMAN registry for ACS with high success rates (94.5%) and low complications rates. MACCE at 1 month after ACS in the ULTRAMAN[28] registry was 2.4%, which was more favorable. ELCA is effective and safe for treating thrombotic lesions.

Saline infusion during the procedure permits passage of light from the catheter tip to the tissue without any interference, avoids micro bubbles formation at the catheter tip and subsequent dissection.

### Ultrasonic thrombolysis

Therapeutic ultrasound selectively disrupts the fibrin matrix and lyses thrombus. Sonothrombolysis requires external transcutaneous therapeutic ultrasound energy and intracoronary delivery of thrombus specific ultrasound contrast agent. Both high- and low-intensity ultrasound enhance clot dissolution but in different ways. High-intensity ultrasound is capable of direct clot dissolution while lower-intensity ultrasound does not act on its own on thrombus but enhances clot dissolution by increasing local concentrations of exogenously administered thrombolytic. Targeted sonothrombolysis (by incorporating a single-chain antibody specific for activated glycoprotein IIb/IIIa into the lipid shell of the micro bubble) to enhance interaction with activated platelets and increase local concentration of micro bubbles seems a plausible option, but randomized human trials failed to show promising results.

## STENTING STRATEGY

### Deferred stenting[29,30]

Large thrombus burden at time of PPCI can impair appropriate stent sizing, stent apposition and final TIMI flow, which can in turn increase the risk of stent thrombosis. Implantation of a stent in a highly thrombotic is also associated with risk of distal embolization and no-reflow with adverse outcomes. Though PPCI and stenting is the current recommended treatment for patients with STEMI, deferred stenting could be an option in selected cases with high thrombus burden and hemodynamically stable. In the catheterization laboratory flow should be restored during primary angioplasty with a wire or gentle balloon dilatation. In case of high thrombus burden, stenting is deferred for an interim period while adjunctive antiplatelet/anti-thrombotic therapy is administered.

In the DEFER-STEMI[31] trial, deferred stenting was associated with higher TIMI flow rates and no incidence of no-reflow/slow flow in high risk population while in DANAMI 3-DEFER[32] deferred stenting for 48 h did not reduce the primary endpoint of all-cause mortality, heart failure, myocardial infarction, or repeat revascularization. Routine deferred stenting is not recommended in ACS except in selective cases.

### MGuard embolic protection stent

The MGuard stent is a bare metal stent with a porous net on its outer surface to trap thrombus debris, while pores allow normal endothelization of the stent through the membrane. It is a balloon-expandable close-cell design bare metal stent, while the first generation was made of stainless steel, the prime was cobalt chromium make. The Micronet is a polyethylene terephthalate microfiber sleeve attached to its outer surface. The custom-designed pores are 5–40-fold smaller than the stent cells and appear to be effective mechanical barrier to thrombus. Although the stent initially proved to improve myocardial perfusion, it failed in terms of safety and secondary end points in the MASTERS and MASTER II STUDY. Higher crossing profile and hence stent delivery, side branch occlusion and high restenosis rates are major limitations.

### STENTYS stent

The STENTYS is a self-expanding Nitinol,[33] sirolimus eluting coronary stent, covered with fine mesh which theoretically was expected to mitigate problems of under sizing and aggressive stenting and prevent stent thrombosis. The APPOSITION IV trial[34] was terminated prematurely due to lack of non-inferiority data. At present, there is no sufficient data for use of covered stent in thrombotic lesions.

## SPECIAL CONDITIONS

### Thrombus in bypass grafts

SVG occlusions are highly thrombotic[34] Acute thrombotic occlusion presents as acute coronary syndrome and PCI if the modality of treatment. Due to the high thrombus burden, PCI caries high risk of distal embolization, no-reflow and periprocedural[34,35] Embolic protection devices reduce periprocedural complications, but they are underused in clinical practice. Among pharmacological alternatives, glycoprotein IIb/IIIa antagonists[36] have been frequently used as a thrombus reduction strategy. Thrombus aspiration (thrombectomy) devices have also been reported to be successful in reducing the thrombus burden and providing distal flow. However, there are no definite guidelines on their use in SVG thrombotic occlusions.

### Stent thrombosis

This is one of the most dreadful and undesired complication of PCI and can be acute, sub-acute or chronic; presenting clinically as life threatening emergency or silent occlusion. Stent thrombosis usually results from residual thrombus after PCI which over time ends up as a fully occlusive thrombus. Treatment includes redo PCI[37,38] with or without thrombectomy and deployment of additional stent, however high chances of re-occlusion and restenosis. Low thrombus burden in a stable patient can be managed with combination of pharmacological agents and manual aspiration. Large burden, with on-going ischemia and hemodynamic instability may need more aggressive mechanical thrombectomy.[39] Stent thrombosis is associated with a larger infarct and poorer outcome than in patients with de novo STEMI.

## CONCLUSION

ICT during PCI presents a unique challenge. Thrombus burden inversely impacts myocardial perfusion, with high thrombus burden resulting in sub optimal PCI results and poor outcome. Management of ICT is a therapeutic challenge and involves a combination of pharmacological and mechanic therapies. Use of aspiration catheters is limited to selective cases as deemed appropriate by the operator. Awareness, prompt recognition, and early institution of aggressive therapy to tackle intracoronary thrombus are the key to successful outcome following PCI.

### Declaration of patient consent

Patient's consent not required as there are no patients in this study.


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### Conflicts of interest

There are no conflicts of interest.


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