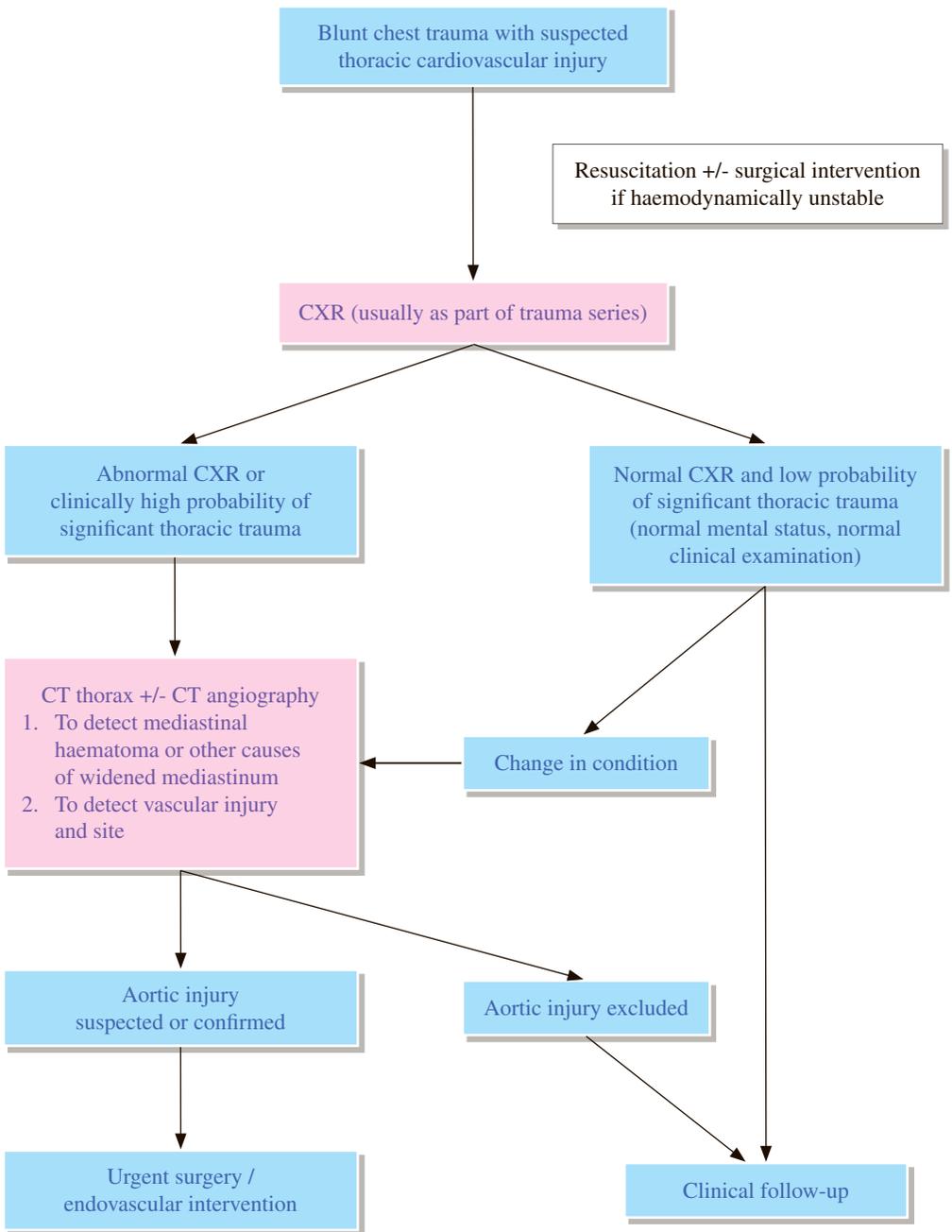


Cardiovascular Radiology



Hong Kong College of Radiologists

CV 1 Blunt chest trauma with suspected thoracic cardiovascular injury



REMARKS

1 Plain radiograph

- 1.1 Remains the primary screening modality despite the advent of newer imaging modalities.
- 1.2 7 – 11% of patients with aortic rupture have an initial normal chest X-ray (CXR).
- 1.3 Most common finding on CXR is widening of mediastinum (90% sensitivity but only 10% specificity for aortic injury).
- 1.4 Radiographic signs of blunt thoracic aortic injury:
 - 1.4.1 Widened mediastinum (defined as transverse dimension \geq 8cm from the left side of the aortic arch to the right margin of the mediastinum or mediastinum to chest-width ratio \geq 25%)
 - 1.4.2 Loss of the aortopulmonary window or loss of definition of the descending thoracic aorta
 - 1.4.3 Widened right paratracheal stripe or paraspinal stripe
 - 1.4.4 Tracheal shift to the right of the T4 spinous process
 - 1.4.5 Left main stem bronchus depression
 - 1.4.6 Nasogastric tube displaced to the right
 - 1.4.7 Left apical pleural cap sign

2 CT and CT angiography

- 2.1 CT has become the reference-standard imaging study for the diagnosis of blunt traumatic aortic injury and has almost completely replaced catheter aortography and transoesophageal echocardiogram (TOE).
- 2.2 CT angiogram (CTA) has high sensitivity and specificity in detection of blunt thoracic aortic injury.
- 2.3 When initial trauma survey and mechanism of injury suggest a low probability of significant thoracic trauma (normal mental status, normal clinical examination and normal CXR), further assessment with chest CT thorax or CTA may not be necessary.
- 2.4 Routine use of CT thorax should be strongly considered in patients with high energy mechanism of injuries, abnormal CXR, altered mental status, distracting injuries, or clinically suspected thoracic aortic injuries.

3 Echocardiogram

- 3.1 Transthoracic echocardiogram (TTE) is helpful in suspected cardiac injury and excluding cardiac rupture and acute valvular injury.
- 3.2 TOE is more sensitive than TTE but more invasive and usually requires sedation, therefore it is rarely used as an initial evaluation.
- 3.3 Limitations include lack availability of cardiologists skilled in performing TEE in the emergency setting; blind spots in distal ascending aorta/arch vessels.

4 MRI

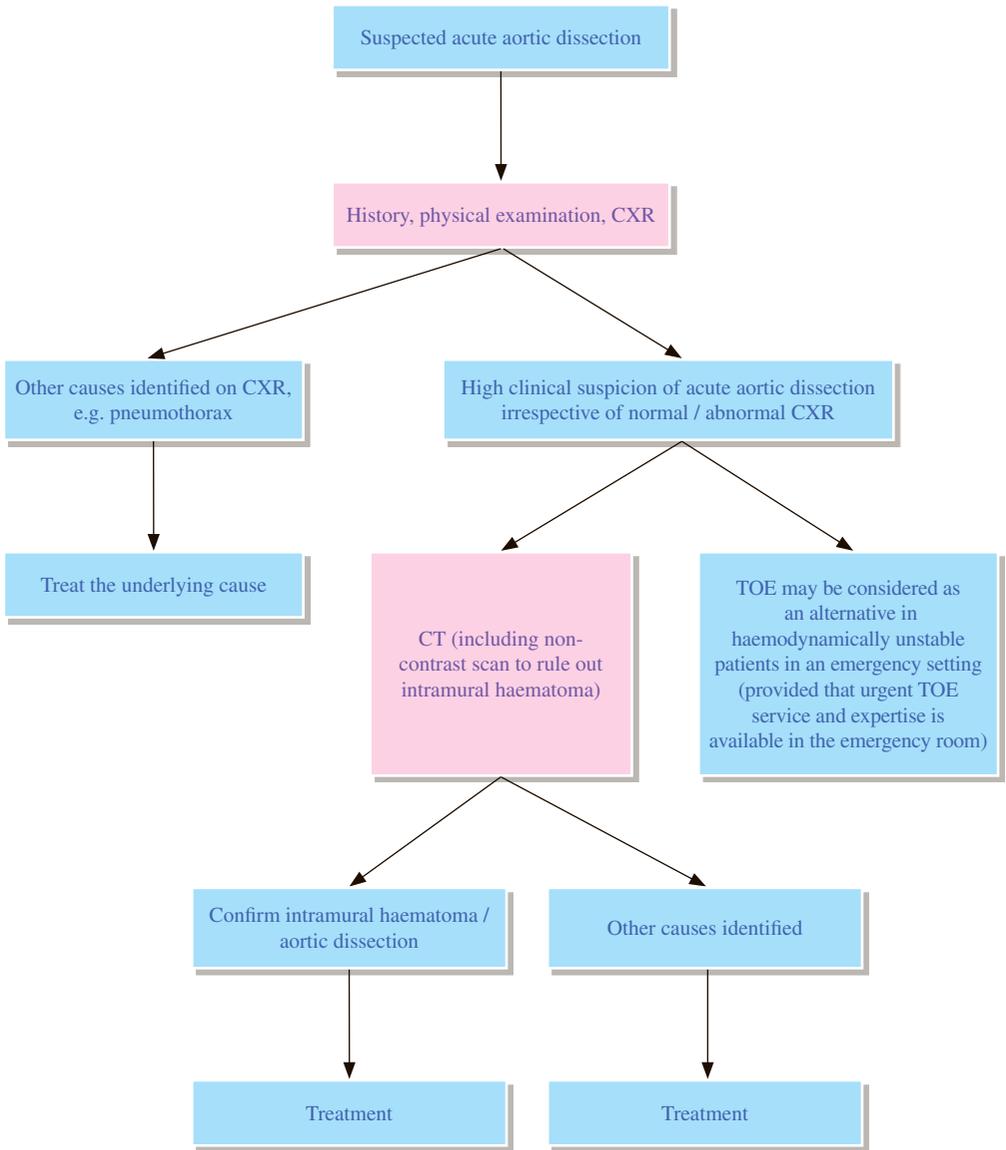
- 4.1 MRI does not have a role in initial evaluation of critically ill, haemodynamically unstable patients.

5 Catheter angiography

- 5.1 Gold standard in evaluating injury to the aorta and its main branches.
- 5.2 Now largely replaced by CTA for initial assessment and reserved mainly for endovascular intervention in confirmed cases.
- 5.3 Angiographically confirmed aortic injury is found in only 10 – 20% of patients with mediastinal widening.

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REMARKS

1 Plain radiograph

- 1.1 Chest x-ray (CXR) is performed primarily to exclude other causes of acute chest pain in patients with suspected aortic dissection, e.g. pneumothorax.
- 1.2 CXR may identify signs suggestive of aortic dissection, such as widening of mediastinum, altered aortic contour, displaced intimal calcification (but these are not always present).
- 1.3 Normal CXR cannot exclude aortic dissection.

2 CT

- 2.1 CT is the recommended definitive investigation for suspected aortic dissection.
- 2.2 CT is minimally invasive, fast, readily available in most hospitals, and instigates less patient discomfort.
- 2.3 CT can provide evaluation of the type and extent of aortic dissection, thereby aiding the clinical management decision.
- 2.4 CT can also detect other causes of chest pain other than dissection, e.g. thoracic pathology.
- 2.5 Non-contrast CT is important to detect acute intramural haematoma.
- 2.6 In case of suspected aortic root involvement, electrocardiogram (ECG) gated CT improves diagnostic accuracy.

3. MRI

- 3.1 MRI is considered as an accurate technique for diagnosis of aortic dissection.
- 3.2 MRI is not advocated as the initial diagnostic test for acute aortic dissection under the following conditions:
 - 3.2.1 Limited scanner and skilled technologist availability on emergency basis
 - 3.2.2 Long examination time which is not favourable for critically ill patients
 - 3.2.3 Patient factors such as inability to hold breath or cardiac arrhythmia which may produce significant artefacts and a non-diagnostic scan
 - 3.2.4 Presence of MRI-incompatible implants and devices including pacemaker
 - 3.2.5 Difficulties in monitoring ill patients in the MRI suite
- 3.3 MRI may be considered in stable patients for the purpose of follow-up of chronic dissection or as an alternative in patients contraindicated for iodinated intravenous (IV) contrast.

4. Echocardiography

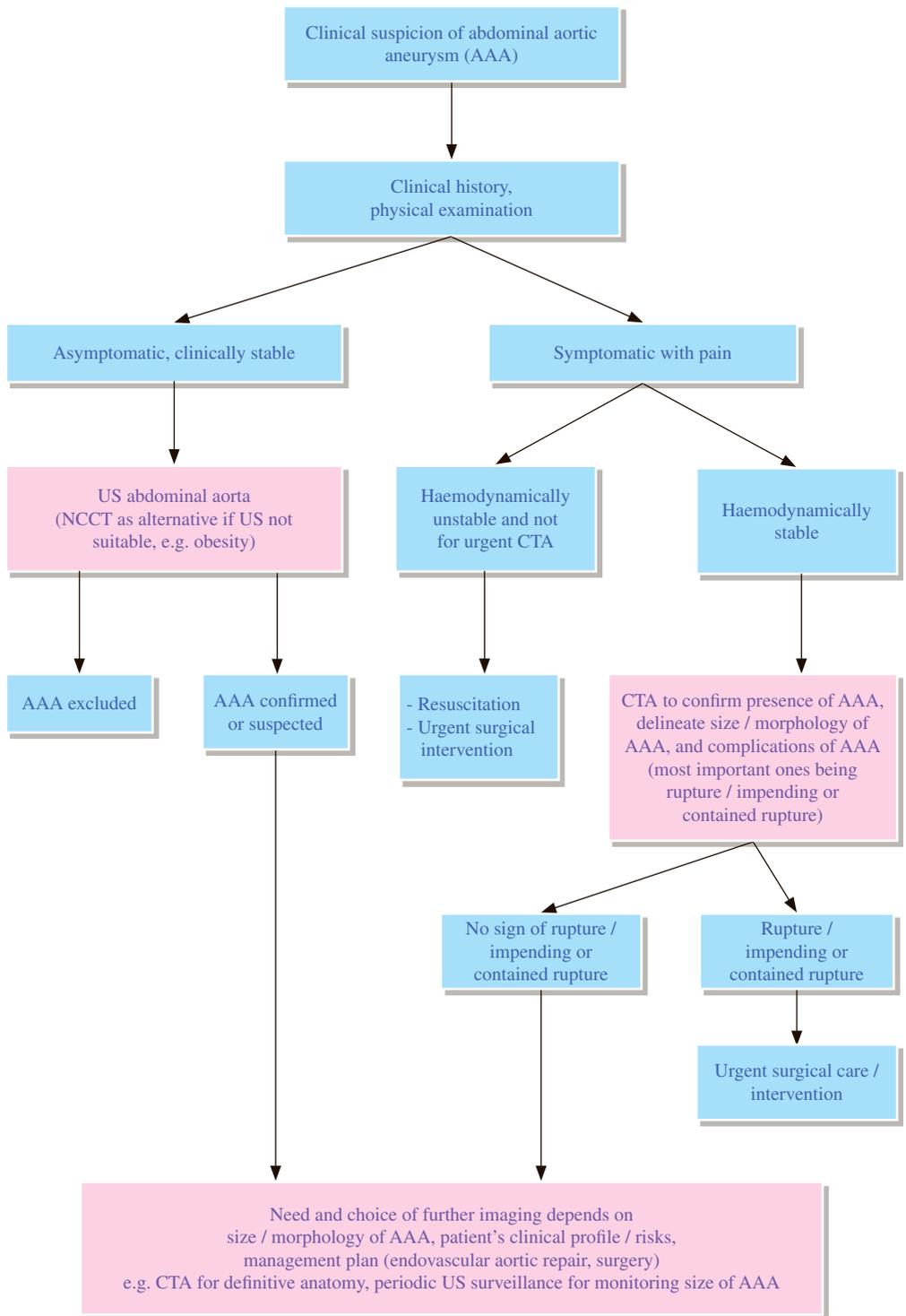
- 4.1 Transoesophageal echocardiography (TOE) has the advantage of bedside use in haemodynamically unstable patients.
- 4.2 It is useful in detecting dissection involving the descending thoracic aorta.
- 4.3 Limitations of TOE include the dependence on operator skill; limited availability of clinicians who are skilled and experienced in performing TOE in emergency setting; the blind area of distal ascending aorta and arch vessels assessment; and the inability to assess distal extent of dissection in the abdomen.

5. Catheter angiography

- 5.1 It was historically the gold standard for diagnosing aortic dissection.
- 5.2 It is now rarely used for the diagnosis of aortic dissection.
- 5.3 It is invasive, requiring direct puncture of the arterial system.
- 5.4 It is used for part of therapeutic endovascular procedures, or for pre-operative angiographic assessment of coronary arteries.

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REMARKS

1 US

- 1.1 Initial examination of choice for asymptomatic, clinically stable patients.
- 1.2 Should be a dedicated study (including complete longitudinal extent of abdominal aortic aneurysm (AAA), any involvement of common iliac arteries, relationship with renal arteries).
- 1.3 Difficult to delineate upper margin of AAA from juxtarenal level or above, and involvement of visceral vessels.
- 1.4 Limitations from patient's body, habitus and acoustic window.

2 CT

- 2.1 Non-contrast computed tomography (NCCT) may be considered when US is not suitable (e.g. obese patients).
- 2.2 NCCT may be considered in patients with or without clinical suspicion of impending or contained rupture.
- 2.3 Computed tomography angiogram (CTA) is best for definitive diagnosis and as a pre-interventional reference.
- 2.4 Useful information obtained from CTA includes morphology and full extent of the AAA, extent of mural thrombus, involvement of branch vessels, three-dimensional (3D) analysis (such as volume rendering, maximum intensity projection (MIP), multiplanar reformats).
- 2.5 First line imaging modality in the emergency setting for the assessment of suspected AAA rupture / impending or contained rupture.

3. MRI

- 3.1 Magnetic resonance angiogram (MRA) may be an alternative to CTA.
- 3.2 Non-contrast and contrast-enhanced sequences can be used.
- 3.3 Non-contrast sequences for patients with severe impaired renal function [glomerular filtration rate (GFR) <30]. Disadvantages of non-contrast MRA include suboptimal assessment of small vessel lesions / small side branches, susceptibility to flowing blood and blooming artefacts.
- 3.4 Other concerns include scanner accessibility, skilled operator / expertise availability, longer scanning time, decreased spatial resolution and general contraindications to MRI (such as pacemaker).
- 3.5 Significant artefacts can be encountered with certain types of stents other than nickel.

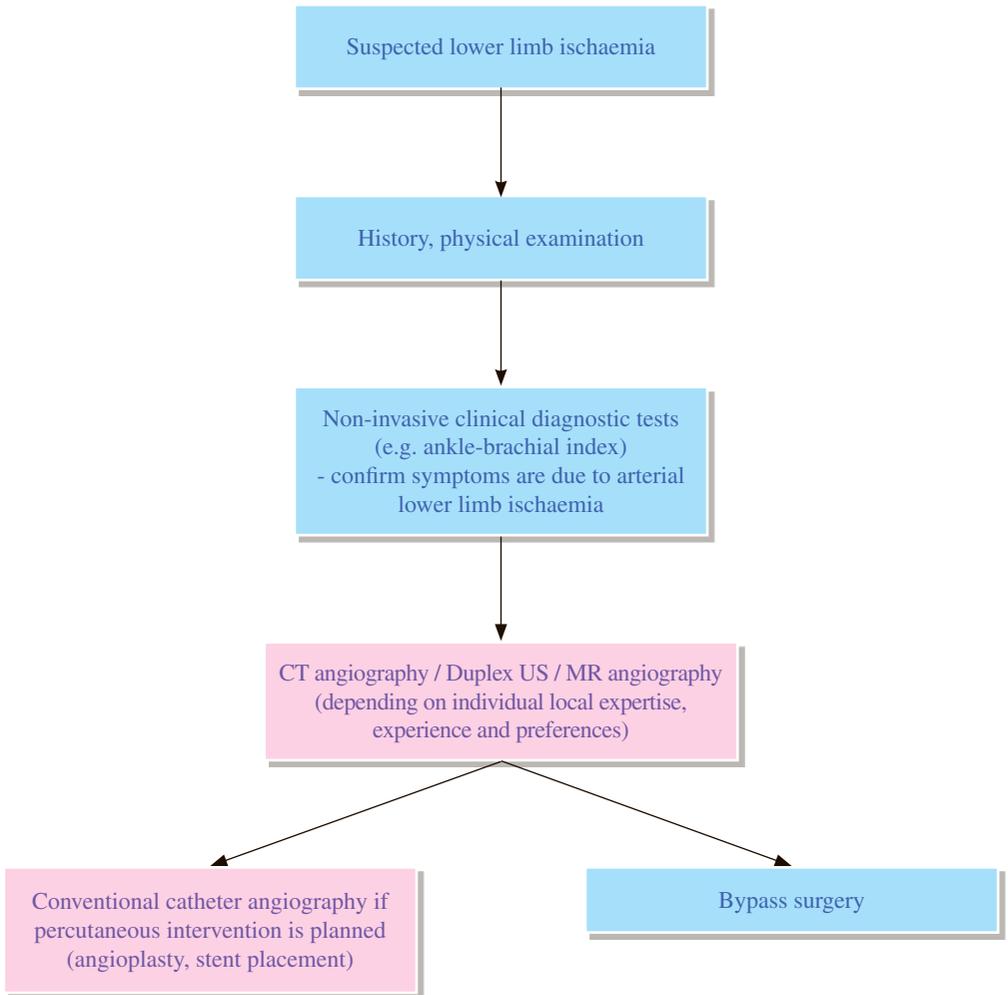
4 Catheter angiography

- 4.1 Usually not for establishing the diagnosis.
- 4.2 Essentially replaced by non-invasive imaging techniques in diagnosis (US, CTA).
- 4.3 May be used for pre-interventional planning.
- 4.4 Essential component of endovascular aortic repair (EVAR) procedure.

- 5 Management of AAA includes conservative approach, open surgery and EVAR; depending on clinical presentation, patient's profile and size / morphology of aneurysm:
 - 5.1 EVAR has emerged as an important treatment option in the management of AAA.
 - 5.2 With the advent of EVAR, pre-interventional imaging has become indispensable for surgical planning (suitability for stent graft deployment, delivery sheath size allowance).
 - 5.3 CTA is accepted as the gold standard for pre-EVAR planning, post-EVAR and post-open repair imaging surveillance.

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REMARKS

1. Non-invasive haemodynamic tests

- 1.1 Include ankle-brachial index (ABI), toe-brachial index (TBI), segmental pressures or pulse volume recordings.
- 1.2 These are important tools for evaluating peripheral vascular disease.
- 1.3 With the presence of normal ABI both at rest and exercise with compressible vessels, atherosclerotic occlusive disease is effectively excluded as a cause of claudication / rest pain and obviates need of further arterial imaging.

2 US

- 2.1 Duplex US imaging can diagnose the location, degree and extent of stenosis down to the level of the knee.
- 2.2 It can also estimate the velocity of blood flow.
- 2.3 Needs skilled and experienced operators, and is a time consuming procedure.
- 2.4 Has limitations which include vessel visualization obscured by bowel gas (abdominal aorta and iliac arteries), dense calcifications and in the setting of multiple sequential lesions.

3. Computed Tomography Angiogram (CTA)

- 3.1 With improvements in multidetector CT (MDCT) technology, CTA has several advantages over digital subtraction angiogram (DSA), including shorter examination time, non-invasive nature, lower complication rates, direct visualization of mural plaque and calcium, visualization of collaterals and three-dimensional (3D) volumetric display and analysis.
- 3.2 CTA has limitations which include difficulties in grading severity of vessel stenosis in presence of dense calcium; suboptimal assessment of calf vessels due to timing issues. Streak artefacts from metallic implants also limit the role of CTA in stent surveillance.
- 3.3 Use of iodinated intravenous (IV) contrast and ionizing radiation are concerns.

4. Magnetic Resonance Angiogram (MRA)

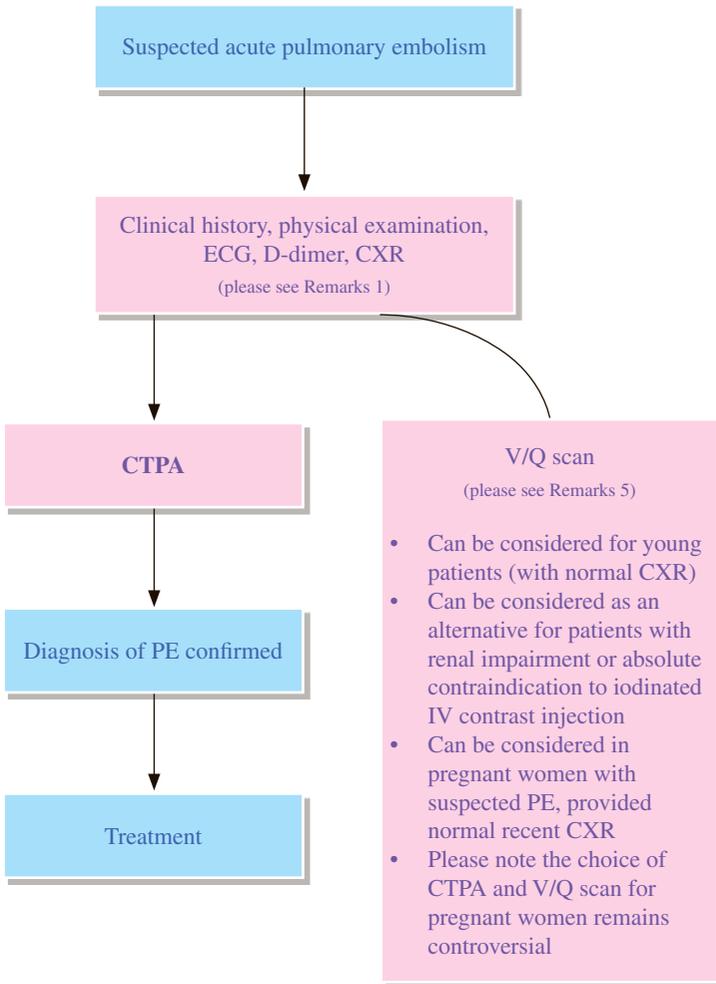
- 4.1 Non-invasive with no ionizing radiation.
- 4.2 Majority of MRI employs contrast-enhanced MRA sequences.
- 4.3 Non-contrast MRI sequences can be considered for patients with renal insufficiency.
- 4.4 Limitations of MRI which affect image quality include longer scanning time (may be more prone to motion artefacts); unreliable visualization of lesions with high flow and turbulence; suboptimal assessment of stent lumen or lumen close to prosthesis.

5. Catheter angiography

- 5.1 DSA is considered the gold standard for imaging of peripheral vascular disease.
 - 5.2 Can allow for intervention such as balloon angioplasty or stenting.
 - 5.3 It is invasive, needs iodinated IV contrast, requires multiple projections and involves ionizing radiation.
 - 5.4 It is now mainly indicated if intervention is planned.
6. Choices of non-invasive investigations (duplex US, CTA, MRA) depend on local expertise and experience.

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REMARKS

1 General

- 1.1 Diagnosis of pulmonary embolism (PE) based on clinical symptoms and signs can be difficult, as chest pain, shortness of breath and tachycardia are non-specific.
- 1.2 To diagnose or to exclude PE, it would be helpful to use an agreed protocol combining clinical features, pretest probability and results of D-dimer assay in order to utilize imaging appropriately, such as Wells' criteria for PE.
- 1.3 Wells' Prediction Rule for Diagnosing PE: Clinical Evaluation Table for Predicting Pretest Probability of PE
 - Symptoms of deep vein thrombosis (DVT): 3 points
 - No alternative diagnosis: 3 points
 - Heart rate >100 bpm: 1.5 points
 - Recent immobilization or surgery: 1.5 points
 - Previous DVT or PE: 1.5 points
 - Haemoptysis: 1 point
 - Malignancy: 1 point
- 1.4 The followings may be considered by referring clinicians as determinants of work-up for PE:
 - 1.4.1 Clinical probability of PE: low 0-1 point; intermediate 2-6 points; high \geq 7 points.
 - 1.4.1.1 If the patient is at LOW RISK, clinicians should use the eight Pulmonary Embolism Rule-Out Criteria (PERC); if a patient meets all eight criteria, the risks of testing are greater than the risk for embolism, and no testing is needed.
 - 1.4.1.2 For patients at INTERMEDIATE RISK, or for those at low risk who do not meet all of the rule-out criteria, use a high-sensitivity plasma D-dimer test as the initial test.
 - 1.4.1.3 Patients at HIGH RISK should skip the D-dimer test and proceed to CT pulmonary angiography, because a negative D-dimer test does not eliminate the need for imaging in these patients.
 - 1.4.2 Alternatively, a two-tier model can be used, if score \leq 4, D-dimer evaluation is needed first.

2 Plain radiograph

- 2.1 Chest x-ray (CXR) is non-specific for PE.
- 2.2 Normal or abnormal CXR cannot exclude presence of PE.
- 2.3 There are no specific findings on CXR which are sufficient to confirm PE.
- 2.4 CXR is useful to exclude other causes of acute chest pain.
- 2.5 A recent CXR is required to allow accurate interpretation of abnormal radionuclide ventilation / perfusion scintigraphy (V/Q scan).

3 Computed tomography pulmonary angiogram (CTPA)

- 3.1 CTPA is the current standard of care and primary imaging modality for detecting PE.
- 3.2 CTPA is highly sensitive and specific.
- 3.3 There are fewer non-diagnostic studies of CTPA than that of V/Q scan.
- 3.4 CTPA can identify features of right ventricular dysfunction which indicates poor prognosis of PE.

4 US

- 4.1 Doppler US of lower extremity veins is useful as there is high association of DVT with PE.
- 4.2 Presence of DVT does not indicate the presence (or absence) of PE, but may increase (or decrease) its likelihood.
- 4.3 In pregnant women with suspected PE and clinical features suggestive of DVT, compression Doppler US of the symptomatic leg veins should be the initial investigation.
- 4.4 Transthoracic echocardiogram (TTE) or transoesophageal echocardiogram (TOE) are generally not indicated for the diagnosis of acute PE, but are useful in the assessment of right ventricular morphology and function.

5 Ventilation / Perfusion scintigraphy (V/Q scan)

- 5.1 Overall decreasing role in evaluation of suspected PE as compared to CTPA.
- 5.2 Scan findings classified by the modified Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) II criteria are reported as “PE present” (high probability), “PE absent” (very low probability or normal), or “not diagnostic” (all other findings).
- 5.3 A normal perfusion scan can obviate the need of ventilation scan, further reducing the dose.
- 5.4 V/Q scan can be an alternative to CTPA in patients without pre-existing pulmonary disease and with normal CXR.
- 5.5 V/Q scan delivers lower radiation dose to the breasts and lower overall maternal radiation dose when compared with CTPA.
- 5.6 V/Q scan can be considered as the first choice of assessment for suspected PE in young patients, particularly during pregnancy (provided normal CXR) and in patients with renal impairment.
- 5.7 Use of single photon emission computed tomography (SPECT) may decrease the rate of non-diagnostic test and improves the diagnostic performance.
- 5.8 V/Q scan is the most sensitive test for chronic pulmonary embolism.
- 5.9 The use of CTPA or V/Q scan in pregnant patients remains a matter of debate.
- 5.10 Not every hospital provides nuclear medicine clinical services. CT is available in most hospitals.

6 MRI

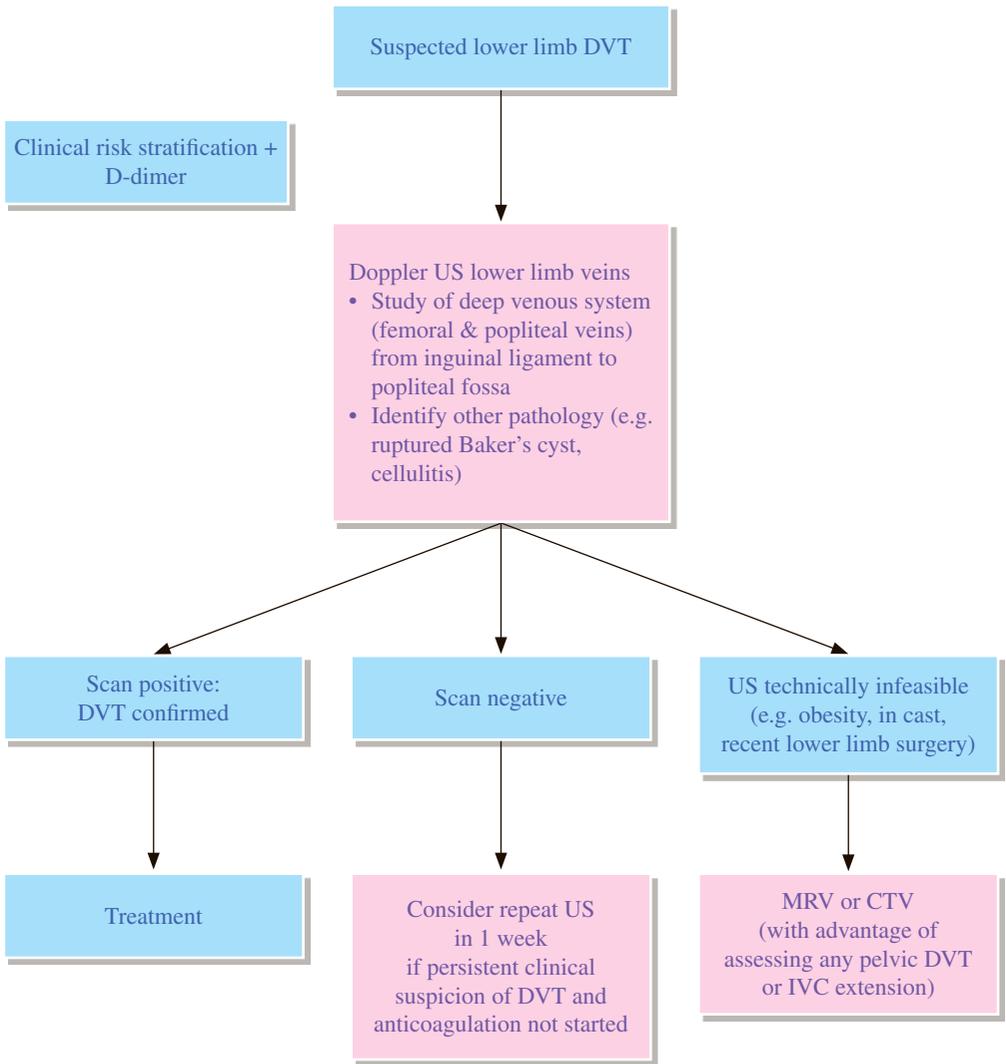
- 6.1 MRI and magnetic resonance angiogram (MRA) are not generally advocated.

7 Catheter-directed angiography of pulmonary arteries

- 7.1 Conventional catheter angiography of pulmonary arteries is generally not necessary for the diagnosis of PE.
- 7.2 Useful if intervention such as thrombectomy or thrombolysis is needed.

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REMARKS

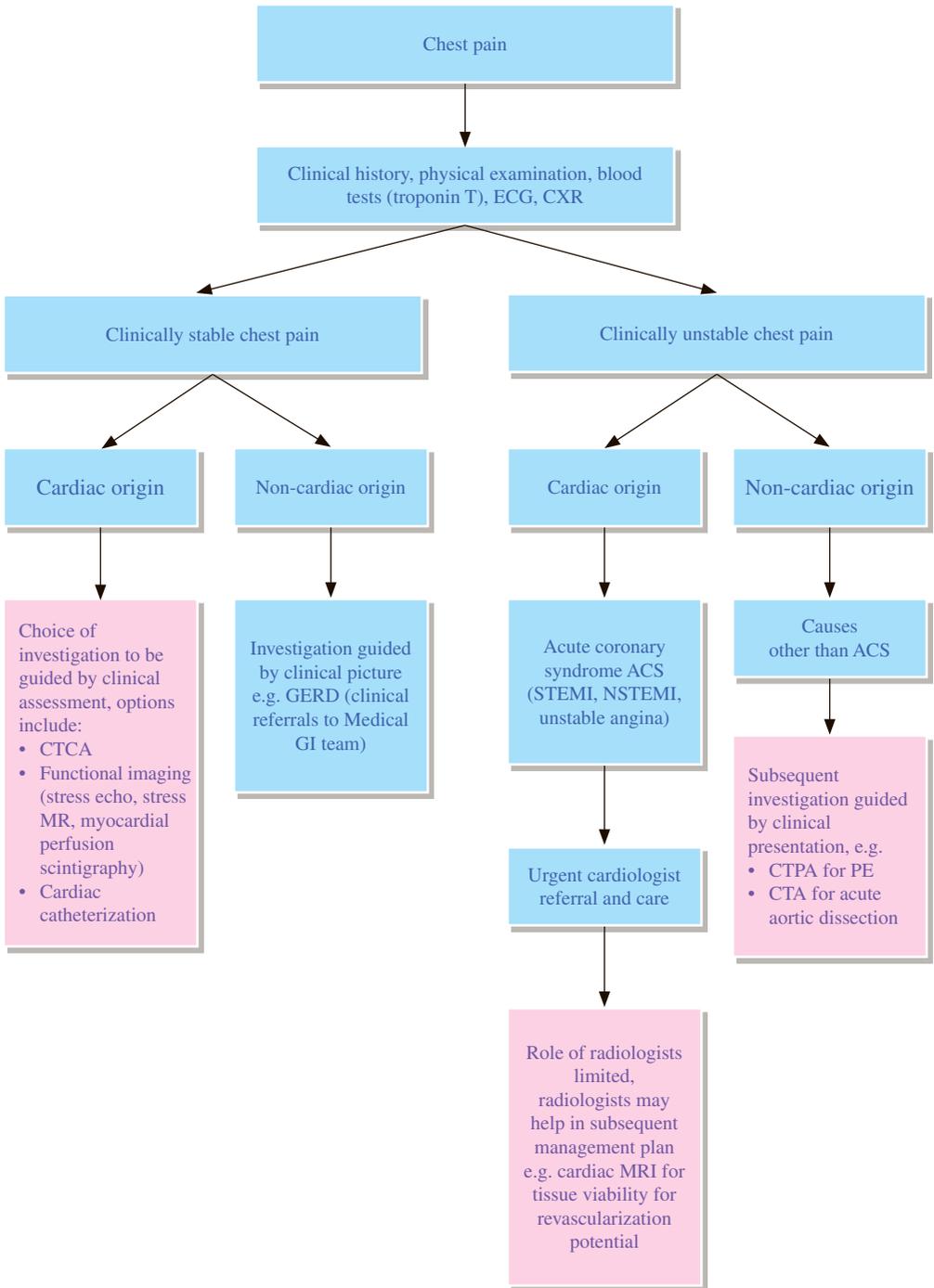
- 1 Initial screening for possible deep vein thrombosis (DVT) includes a combination of clinical risk stratification score (e.g. Wells' score) and plasma D-dimer assay.
- 2 Both clinical risk stratification scoring and D-dimer assay have limitations. Imaging is typically required for confirmation of DVT.
- 3 **US**
 - 3.1 Preferred primary imaging modality for diagnosing proximal DVT (from inguinal ligament to popliteal fossa).
 - 3.2 Non-invasive, no exposure to ionizing radiation or iodinated contrast media, widely available and easily performed at patient's bedside.
 - 3.3 Compression US is most important, often combined with real time Doppler imaging.
 - 3.4 Duplex US for augmentation of venous flow rarely provides additional information.
 - 3.5 High sensitivity (range: 93.2% - 95.0%, pooled sensitivity 94.2%) and high specificity (range: 93.1% - 94.4%, pooled sensitivity 93.8%) for diagnosing proximal DVT.
 - 3.6 Much lower sensitivity for diagnosing distal DVT (below knee).
 - 3.7 Difficult to assess pelvic DVT using US.
 - 3.8 DVT limited to infrapopliteal calf veins (distal DVT) often resolves spontaneously and is rarely associated with pulmonary embolism. Treatment of distal DVT remains controversial. US calf veins is not recommended as a routine.
 - 3.9 When there is persistent high clinical suspicion of DVT in patients who had an initial negative US and in whom anti-coagulation was not started, follow-up US in 1 week may be considered to exclude a calf thrombus that is propagating proximally.
- 4 **Magnetic resonance venography (MRV) / Computed tomography venography (CTV)**
 - 4.1 Viable imaging options in patients in whom US is technically not feasible (e.g. in cast, obesity); and in patients with high suspicion of pelvic DVT or non-diagnostic US examinations.
 - 4.2 Distinct advantage over US in demonstrating pelvic vein / inferior vena cava (IVC) involvement and extravascular pathology that may account for DVT.
 - 4.3 MRV: no ionizing radiation, can be done with or without contrast; limitation include scanner availability, longer scanning time, patient factors and implants / devices which are MRI incompatible.
 - 4.4 CTV: involves ionizing radiation and use of intravenous contrast; CTV may be incorporated into CT investigation of pulmonary embolism and proximal DVT.

5 Contrast X-ray venography

- 5.1 Historic gold standard for diagnosing DVT.
- 5.2 Rarely used nowadays.
- 5.3 Has a role in assessing recurrent acute DVT in patients with a previous history of DVT and in whom venous anatomy is complex.

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REMARKS

1. There are many aetiologies of chest pain.
 - 1.1 **Cardiac origin** such as acute coronary syndrome (ACS) [including ST-segment-elevation myocardial infarction (STEMI), non-ST-segment-elevation myocardial infarction (NSTEMI), unstable angina], myocarditis, pericarditis.
 - 1.2 **Non-cardiac origin** such as pneumothorax, pulmonary embolism, acute aortic dissection, pneumonia, pulmonary carcinoma.
Gastroesophageal reflux disease (GERD) is the commonest cause of non-cardiac cause of chronic chest pain.
2. Initial clinical assessment [history, physical examination, electrocardiogram (ECG), blood test - troponin, chest X-ray (CXR)] is mandatory to distinguish clinically stable and clinically unstable patients presenting with chest pain.
3. For clinically stable chest pain; approaches are as discussed below:
 - 3.1 National Institute for Health and Care Excellence (NICE) guideline (CG 95): Chest pain of recent onset: assessment and diagnosis
 - 3.1.1 Clinical assessment (based on clinical history and physical examination) is important.
 - 3.1.2 64-slice (or above) CT coronary angiography (CTCA) if clinical assessment indicates typical or atypical angina; or clinical assessment indicates non-anginal chest pain but 12-lead resting ECG indicates ST-T changes or Q waves.
 - 3.1.3 Non-invasive functional testing for patients with confirmed / known coronary artery disease (CAD) (such as previous myocardial infarction, revascularization, previous angiography) when uncertain whether chest pain is caused by myocardial ischaemia.
 - 3.2 American College of Radiology (ACR) Appropriateness Criteria: Chronic chest pain
 - 3.2.1. Low to Intermediate probabilities of CAD (2012)
 - 3.2.2. Stress studies (myocardial perfusion scintigraphy, stress cardiac MRI, stress echo); CTCA
 - 3.3 American College of Radiology (ACR) Appropriateness Criteria: Chronic chest pain
 - 3.3.1. High probability of CAD (2016)
 - 3.3.2. Myocardial perfusion scintigraphy, stress echocardiography, stress cardiac MRI
4. For clinically unstable chest pain, if initial clinical assessment indicates clear ACS (STEMI, NSTEMI, unstable angina), patients should be urgently taken care of by cardiologists.
 - 4.1 Roles of radiologists are limited in this scenario.
 - 4.2 Radiologists may have a role in subsequent management plan such as,
 - 4.2.1 Assessment of tissue viability for revascularization potential (cardiac MRI).
 - 4.2.2 Assessment of coronary artery anatomy (CTCA), in cases of complex vessel anatomy (chronic total occlusion, anomalies) found in invasive cardiac catheterization, and planning of percutaneous coronary intervention (PCI) / coronary artery bypass graft (CABG).
 - 4.3 For a certain subset of patients who present with clinically stable ACS (unstable angina/NSTEMI) and not selected for urgent catheter catheterization, a number of imaging modalities can be considered for evaluation, e.g. myocardial perfusion scintigraphy, CTCA, cardiac MRI, stress echocardiography.

- 5 For clinically unstable chest pain, if initial clinical assessment suggests conditions other than ACS, subsequent imaging investigations shall be guided by the individual clinical presentation.
 - 5.1 CXR is routinely/universally performed and may give clues to the causes of chest pain (such as pneumothorax, widened mediastinum indicating possibility of aortic dissection).
 - 5.2 Normal CXR cannot rule out significant pathology.
 - 5.3 Computed tomography pulmonary angiogram (CTPA) for suspected pulmonary embolism.
 - 5.4 CT aortogram for suspected intramural haematoma, aortic dissection.
 - 5.5 Cardiac MRI for suspected myocarditis.
 - 5.6 Echocardiography for pericardial effusion, infective endocarditis.
 - 5.7 US abdomen for acute cholecystitis or acute pancreatitis which may be the cause of chest pain; CT abdomen for suspected perforated hollow viscus which may cause excruciating chest pain.

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