

ACUTE CHEST PAIN ASSESSMENT

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Acute chest pain is one of the major clinical emergency conditions. Various differential diagnoses have to be considered, some of them are potentially life-threatening. A standard chest radiograph is usually the first imaging study. However, conventional X-rays are of limited value in this respect. Computed tomography (CT) assessment for vascular pathologies of the chest can be split up into three major categories. Pulmonary embolism, acute aortic syndromes and coronary artery disease (CAD) require a rapid, reliable and effective diagnostic pathway allowing for an immediate therapeutic decision thereafter. A simple and objective cross-sectional modality should ideally be available on a 24/7 basis. Multidetector-row spiral computed tomography (MDCT) scanners are being located nearby the emergency ward or the operation theatre in order to facilitate direct and definite assessment for these critically ill patients.

At first, it should be checked whether a CT angiography (CTA) of the coronaries is technically feasible with the equipment available, as an ECG-synchronization of the data set is a prerequisite for that. Latest MDCT scanners are capable of such an "one-stop-strategy". Cardiac imaging can be incorporated into established examination standard operating procedures for non-cardiac vascular and non-vascular imaging of chest disorders. This approach can be summarized with the buzz word "triple rule-out". Initial studies showed that low to moderate risk patients for acute coronary syndromes presenting to the emergency department are safely evaluated by this method. On the one hand, additional diagnostic cardiac testing can be precluded with no adverse outcome for the majority of referrals. On the other hand, the presence of moderate to severe CAD as well as a noncoronary diagnosis explaining the presenting complaint can be depicted in a (smaller) number of patients as well.

The contrast medium application should be adapted according to the differential diagnoses that have to be addressed: Firstly, an opacification of the pulmonary arteries is needed for the exclusion of pulmonary embolism. Secondly, optimal density values are needed for the arterial vessels (aorta, coronaries). Therefore, an opacification of the pulmonary circulation **and** the systemic circulation is needed at the same time. On the other hand, triple rule-out protocols usually require a low pitch (0.2 – 0.4) to collect sufficient data for the ECG-gated image reconstruction. This causes a quite long data acquisition which will be in the range of 15 – 25 s. Hence, advanced contrast medium application includes biphasic and even triphasic protocols for this “one-stop-shop” approach. Dedicated contrast material injections might not be needed anymore with second generation dual-source systems, as scan times for the entire chest can be brought down to less than 1 s using high pitch scanning protocols (up to 3.2).

Medication directly on the CT-table with glyceryl trinitrates (GLN) s.l. might be added for vasodilatation. A caudo-cranial scan direction is favorable for optimal results. Patients should be instructed to hold their breath after mild inspiration in order to avoid a Valsalva-effect and a split enhancement within the pulmonary vasculature. Transient interruption of contrast in the pulmonary arteries represents a flow-related phenomenon associated with an increased inferior vena cava contribution to the right side of the heart.

A differentiated approach utilizing MDCT for emergency conditions in so called “chest pain units” is under evaluation in many centers.

Acute pulmonary embolism

Due to its mostly unspecific clinical presentation, pulmonary embolism (PE) is often referred to as the great masquerader and remains a diagnostic challenge. Accordingly, distinct diagnostic algorithms are needed to assist the general clinical assessment (e.g. using the Wells score) and to optimize the use of diagnostic tests, especially in an emergency department setting. In patients with a low clinical probability of PE, the most cost-saving strategy involves plasma D-dimer measurements, a degradation product of cross-linked fibrin. Due to its high sensitivity, D-dimer ELISA have been advocated as the first-line

test for ruling out PE in outpatients, provided the specific assay has been validated in an outcome study. However, the specificity of fibrin for venous thromboembolism is poor. Fibrin is produced in a wide variety of conditions, such as cancer, inflammation, infection and necrosis. Additionally, it is not useful in elderly or inpatients, as it is normal in less than 10% of patients. Therefore, MDCT is accepted as an appropriate initial test in patients with intermediate and high clinical suspicion of PE.

Several studies have shown that there is no diagnostic need for an ECG-synchronization of the data set, as this clinical question is safely answered by a “standard” CTA. Already 4-slice MDCT platforms have proven excellent negative predictive values. Despite the direct visualization of thrombi and emboli, secondary findings can be delineated. These include areas of decreased density as well as consolidated areas localized within the lung parenchyma. Right heart failure can be indirectly assessed by an enlargement of the right heart chambers as well as straightening of the interventricular septum and bowing into the left ventricle. Also demonstration of ancillary findings and suggestion of the true alternate diagnoses are clinically extremely beneficial. CTA may provide either additional findings or alternate diagnoses in over half the examinations interpreted as negative for PE.

Therefore, MDCT scanning technique is nowadays the “gold standard” and has been incorporated into dedicated guidelines for the diagnostic assessment of clinically suspected PE.

Acute aortic syndromes

A sudden onset of tearing and ripping chest discomfort can be summarized as the classical clinical presentation for acute thoracic aortic syndromes. Poorly regulated hypertension and soft-tissue disorders like Marfan’s disease are common underlying causes for the development of intramural hematoma, aortic dissection as well as aortic aneurysms and rupture. Different therapeutic regimens will be necessary for different clinical conditions in vascular aortic pathology. Pathologies within the chest are differentiated for their anatomic region, as the location is of major importance (thoracic, thoraco-abdominal,

abdominal aorta). For example, an involvement of the ascending aorta usually constitutes a surgical emergency.

MDCT is nowadays the first-line imaging test in the assessment of acute aortic syndromes. The 4-slice MDCT platforms already allow for a combined assessment of the thoracic and abdominal aorta within a single breathhold, therefore necessitating a single contrast medium delivery, only. CTA of the aorta has proven to be superior in diagnostic accuracy to conventional arteriography. It also allows an immediate 3D assessment of the pathology as well as an individual decision on behalf of the imaging findings matched with the clinical course and the general therapeutic options. The iliac and common femoral arteries are usually included to provide an overall picture of the vascular anatomy.

Pathologies originating from the descending aorta (e.g. Stanford B dissection) usually can be diagnosed safely with a “standard” (sub-)millimeter collimated MDCT protocol. Dedicated diagnostic work-up of the ascending aorta, however, may remain a formidable task. Cardiac motion artifacts degrade the diagnostic quality of thoracic cardiovascular CT imaging. Retrospective ECG-synchronization minimizes transmission of cardiac motion, also in more extensive scanning volumes in the thorax. On the other hand, the increase in scan time (inherent in data oversampling) will limit the overall scan range for 4-slice and 16-slice MDCT scanners.

For the assessment of pathology near a coronary artery as well as for potential aortic valvular involvement, however, an ECG-synchronization is indispensable. Therefore, a differentiation for the diagnostic MDCT-pathway is warranted, e.g. utilizing spiral data acquisition with retrospective ECG-gating for a suspected Stanford A dissection, thus being limited in the overall scan volume.

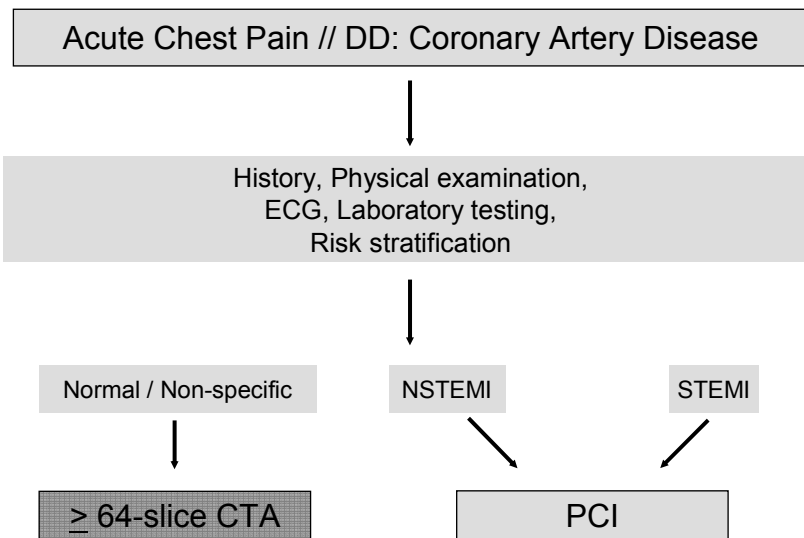
Therefore, referring physician and radiologist should discuss what kind of exam is clinically essential, based on the clinical diagnosis and individual presentation of the patient. These technical limitations will be overcome with \geq 64-slice MDCT examinations and dual-source CT technique. Anyhow, ECG-synchronization will still be a point of concern, especially in terms of radiation protection. Low pitch protocols with consecutive longer data acquisitions will

result in a dose penalty, which can easily exceed 15 mSv. Alternative scanning techniques (ECG-triggered high pitch spiral data acquisition using second generation dual-source CT scanners) might overcome these limitations.

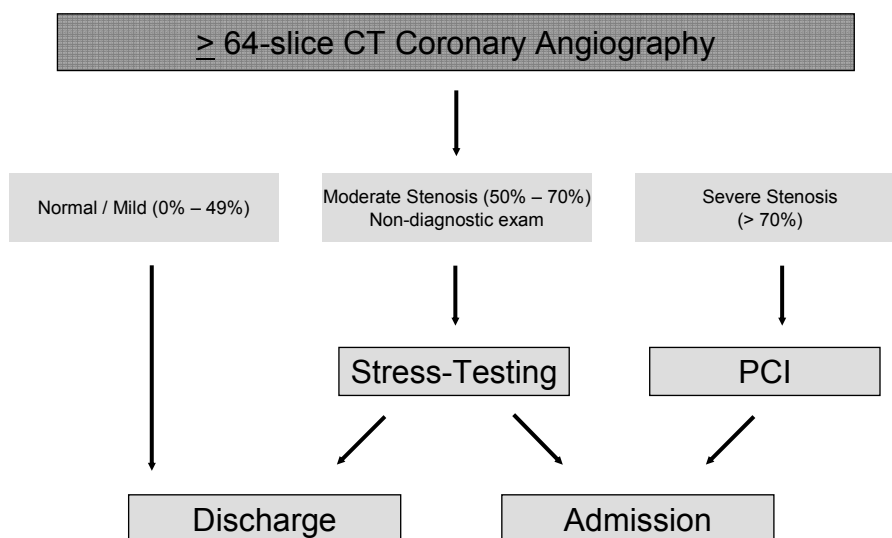
Acute CAD

A combined assessment of the lung parenchyma, the vasculature of the chest as well as a depiction of the heart and the coronaries can be done with the latest scanner technology available (256-slice, 320-slice MDCT per rotation; dual-source technology). From today's standpoint, significant coronary stenosis can also be safely excluded using 64-slice MDCT platforms with retrospective ECG-gating. For 64-slice scanners, the use of beta-blockers is still needed to bring down the heart rate of the patient, as the temporal resolution is still not sufficient for imaging of unselected patients. Heart rates of 60 – 65 bpm are always recommended to achieve optimal image quality. This premedication, however, will limit the options under emergency conditions, as this might be time-consuming, and several contraindications have to be taken into account.

Patients with an intermediate pre-test likelihood for a CAD are especially of major interest. Recently, a dedicated graduated scheme was published in a consensus statement of the North American Society of Cardiac Imaging and the European Society of Cardiac Imaging. Hence, MDCT is especially valuable in the exclusion of CAD in patients with a normal and non-specific laboratory testing in combination with a negative ECG. On the other hand, it should also be stressed that CTA of the coronaries does not add important information in patients with a high pre-test likelihood and known CAD.



Pathway for patients with acute chest pain, in which CAD is one potential differential diagnosis. In case of a well-known CAD and a high pre-test likelihood, a percutaneous catheter intervention (PCI) should be performed. In case of non-specific symptoms, a MDCT angiography of the coronaries is technically feasible for the exclusion of CAD.



According to the results of the coronary MDCT angiography, the patient can be discharged (exclusion of relevant CAD) or should be treated (proof of hemodynamically relevant stenoses). In indeterminate cases as well as in non-conclusive exams, additional stress-testing is recommended (modified from: Stillman AE, et al.: Use of multidetector computed tomography for the assessment of acute chest pain: a consensus statement of the North American Society of Cardiac Imaging and the European Society of Cardiac Radiology. *Eur Radiol* 2007; 17: 2196 – 2207).

In summary, modern MDCT equipment allows for a robust and straight-forward diagnostic work-up for acute chest pain in the emergency situation. The latest scanner technology permits acquisition of well-opacified images of the pulmonary arteries, the thoracic aorta as well as the coronary arteries. A diagnostic examination quality is guaranteed, even in acutely ill patients. Using first generation dual-source CT, overall sensitivity rates of 98% as well as a 100% negative predictive value for the exclusion of clinically relevant CAD have been reported. In order to avoid an over utilization of this method, precise indications for its use will have to be determined.

If a sophisticated clinical assessment favors PE or an acute aortic syndrome, an ECG-synchronized spiral data set of the entire chest might not be the optimal solution for the patient due to radiation safety necessities. From a radiological standpoint, a dedicated triage is mandatory, especially in younger patients.

Further studies will prove whether this clinical pathway is also beneficial in the long run, if patients with a negative MDCT / dual-source CT examination are discharged directly from the emergency ward without further diagnostics (and therapy).

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