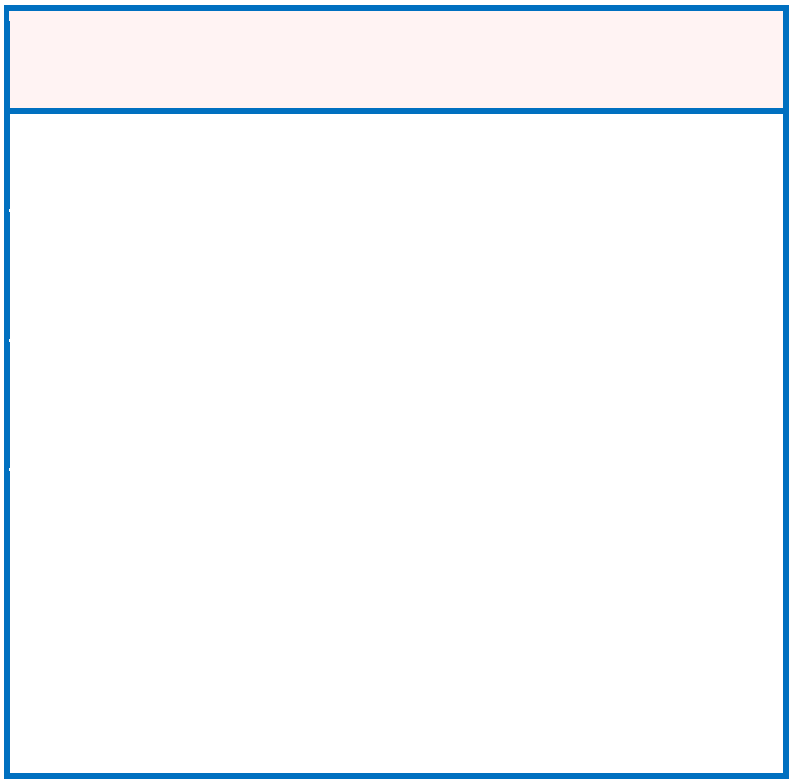

Spontaneous coronary artery dissection (SCAD) is increasingly recognised as an important cause of acute coronary syndrome (ACS), particularly in young and middle-aged women. However, management is distinct from ACS due to atherosclerotic disease. There is a limited evidence base for acute and longer term management and data is entirely based on retrospective and observational studies, with no large scale randomised controlled trials. Based on this limited data and largely expert consensus, position statements have been published by the American Heart Association (1) and the European Society of Cardiology (2). Most recently, a large international cohort study was published in 2021 (3) looking at the role of percutaneous coronary intervention (PCI) in SCAD. This editorial will focus on diagnosis and management, outlining current guidelines and evidence and future areas for research.

SCAD has historically been underdiagnosed, but with increasing recognition in recent years is estimated to cause up to a third of all ACS cases in women aged less than 50 years (4). However, estimating prevalence in population based studies has been limited by incomplete clinical data and inconsistent angiographic criteria (5). SCAD is also the most common cause of pregnancy-associated ACS (6).

There are two main hypotheses (2, 5) for the -
theory whereby the spontaneous development of a dissection flap allows blood to enter the sub-intimal space from vessel lumen. The alternative hypothesis is -
of a spontaneous haematoma within the vessel media compresses blood flow within the true lumen.

-
supported by most SCAD cases not showing a communication between true and false lumens on angiography, and serial imaging showing intramural haematoma formation prior to intimal dissection (7). Additionally optimal coherence tomography (OCT) imaging suggests that the false lumen is under pressure, and it is rupture of this haematoma that forms the communication with the true lumen (8).

Given the overwhelmingly increased prevalence in women, and association with pregnancy, SCAD is likely to be related to sex hormones but an exact mechanism has not been found (2). There is no evidence currently to suggest that SCAD is related to contraceptive hormone use or postmenopausal hormone replacement therapy (5).

SCAD has a well-documented association with underlying arteriopathies, most commonly fibromuscular dysplasia (1, 9), as well as connective tissue disorders and systemic inflammatory conditions. In addition, there does appear to be a familial preponderance, and the lack of traditional cardiovascular risk factors in this patient group would also support a genetic basis for the condition, despite the lack of a strongly familial monogenic pattern of inheritance (1, 5).

Patients with SCAD usually present with typical ACS symptoms of chest pain, diaphoresis, and shortness of breath. They can also present in acute heart failure, with arrhythmias, or in cardiac arrest. One retrospective study looking at 53 SCAD patients with ST elevation MI (STEMI) among a cohort of 5208 consecutive STEMI patients (10), SCAD patients were more likely than those with atherosclerotic disease to develop cardiogenic shock, or have left main stem (LMS) or left anterior descending (LAD) disease.

The ESC position statement (2) also describes Type 4 SCAD which is complete vessel occlusion, which usually occurs in distal vessels.

SCAD can be difficult to diagnose on angiography, and may be misdiagnosed as atherosclerosis, spasm, or normal coronaries. If appearances are unclear, intracoronary imaging, nitrates or other imaging modalities can aid diagnosis (5).

Intracoronary imaging plays an important role, particularly in type 3 lesions or when PCI is being considered. However, it carries risks beyond the already increased risk of diagnostic angiography in these patients, mainly of extending dissection with the wire or catheter, or during contrast injection (1). It is advised to limit assessment to the proximal part of the lesion to minimise complications (2, 5). Overall OCT images provide better resolution than IVUS (1, 5) for imaging intimal tears and false lumens. However the advantage of IVUS is that less pressurised contrast injection is required (2) than for OCT.

Other imaging techniques

Cardiac magnetic resonance imaging can also support a diagnosis of SCAD by illustrating delayed gadolinium enhancement in the corresponding territory of suspected dissection (5), or suggest an alternative diagnosis such as myocarditis. A normal CMR however may not exclude SCAD (14).

CT coronary angiography is increasingly used in low and intermediate risk acute chest pain patients, but is of limited use in acute SCAD patients as a normal CT does not rule out the diagnosis (1). CT has relatively limited spatial resolution of small vessels where dissection is most likely to occur, and it is more likely that haematomas or abrupt changes in vessel calibre will be seen rather than dissection planes (5). No large scale studies have been caried out to determine the specificity or sensitivity of CT in acute SCAD (2, 5). However, CT may be useful as a follow up tool to confirm healing, especially where there is dissection in proximal vessels, and to avoid a further invasive test (2, 15).

The aim of acute management is to restore myocardial perfusion and blood flow in order to prevent

PCI is considered for high risk patients: those with evidence of ongoing ischaemia, cardiogenic shock, ventricular arrhythmias, or high risk anatomy such as left main stem dissection (16, 11, 5, 1). There are no randomised controlled trials looking at revascularisation in SCAD patients. Particularly in stable patients with high risk anatomy, it is unclear if PCI is of benefit. However, an international cohort study published last year (3) looked at 215 SCAD patients who underwent PCI, matched with a cohort of 221 conservatively-managed SCAD patients, and found that more than 90% of patients undergoing PCI had ST elevation, TIMI 0 or 1 flow, or proximal dissections. These were also high risk PCI procedures with one third requiring either unplanned LMS stenting, more than three stents, or more than or equal to 50mm stent length, and despite this nearly two thirds had residual area of unstented dissection.

There is a significantly higher risk of PCI complications or failure in SCAD patients, quoted as between 38.6% (3) and 53% (11) in various studies. In addition to the risks of the diagnostic angiogram, passing the coronary wire carries risk of extending the dissection, and the fragile nature of the vessels and intramural haematoma makes PCI unpredictable. During PCI, haematomas can spread requiring multiple and longer stents (5) with increased long term risk in-stent thrombosis or restenosis. Conversely, later haematoma resorption can lead to stent malapposition (5). The cohort study from Kotecha et al in 2021 (3) found that PCI in this group of SCAD patients required on average an extra 0.7 stents and 21.4mm stent length compared to BCIS national audit data (17) for PCI for all causes. This study also found an increased frequency of complications with type 2 dissections; the authors suggest that the presence of fenestrations between the true and false lumens allow decompression of the haematoma and reduce risk of PCI complications.

There are no comparative studies of PCI strategies for SCAD, but a number of techniques have been suggested (1, 18-21), including using long stents to exceed the lesion edges by 5-10mm in order to cover areas of spreading haematoma when the stent is dilated. Alternatively, stenting the distal and proximal edges first to prevent propagation has been suggested, as well as stenting directly without pre-dilatation. Cutting balloons have also been used to fenestrate intramural haematoma and allow decompression (18). Some also advise not using stents but instead performing balloon angioplasty alone, or using bioresorbable stents. Overall the literature suggests that unlike in atherosclerotic disease,

Despite the increased risks of PCI in SCAD patients, Kotecha et al (3) found that over a median follow up of 900 days there was no difference in major adverse cardiovascular and cerebrovascular events between the PCI

The rate of recurrent SCAD have been variously reported between 10% and 30% (1, 5), although data is complicated by varying definitions and time of follow up of different studies. Generally, recurrence is defined as an apparent new dissection in a location not suggesting extension of prior SCAD, and associated with symptoms and raised troponins (5). The risk factors for recurrence are not well understood, with severe coronary tortuosity being the only identified risk factor (12). The only treatments that have shown benefit in reducing recurrence are beta-blockers, and blood pressure control (5, 24). There has been no association between rates of recurrence and antiplatelet treatment.

the paucity of evidence on outcomes should be shared with women before potentially life-changing advice to avoid pregnancy is given. If pregnancy does occur, these patients are high risk (2) and should be managed with close collaboration between obstetricians and cardiologists.

The association with female sex and pregnancy also gives rise to anxiety about hormonal-based contraception. Although not specifically studied in SCAD patients, progesterone-only methods have been recommended in preference to oestrogen-containing methods (5). Progesterone-containing contraception would also help excessive menstrual blood loss for patients on antiplatelets.

Routine repeat invasive angiography is not recommended due to the risk of iatrogenic dissection. It would be indicated only if recurrent symptoms, chest pain with abnormal functional testing, or to confirm healing of high risk lesions, such as left main stem (1). CTCA can be considered in conservatively managed patients with proximal to mid vessel dissections to confirm healing (15), but for more distal lesions CT is often not useful and does carry radiation risk in younger patients.

Given the documented associated with underlying arteriopathies (9), it is recommended by the AHA and ESC that screening for extracoronary vascular abnormalities with CT or MR angiography should

SCAD is an important differential to consider in patients presenting with ACS. Diagnosis can be challenging, and diagnostic angiography itself carries increased risks. However, it is key that SCAD is differentiated from atherosclerotic ACS early as management in terms of medical therapy and indications for revascularisation are quite different. Conservative management is preferred for clinically stable patients, as revascularisation is high risk. There is little evidence for long term medication or how to prevent recurrence, and considerable future research is needed in this patient group to guide early and long term management.

1. Hayes SN, Kim ESH, Saw J *et al.* Spontaneous coronary artery dissection: current state of the science: a scientific statement from the American Heart Association. *Circulation* 2018;137:e523-557
2. Adlam D, Alfonso F, Maas A *et al.* European Society of Cardiology, Acute Cardiovascular Care Association, SCAD study group: a position paper on spontaneous coronary artery dissection.