Evaluation of cardiac risk in dental patients

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Key points

Provides a tool for cardiac risk assessment for general dental practitioners and dental specialists to supplement other commonly used methods such as the ASA scale.	Provides detail on how to evaluate the control of conditions associated with cardiac risk as well as the patient's functional capacity.	Offers practical advice on the implications for dental treatment in individual cases.

Patients with cardiac disease, cardiac symptoms and related co-morbidities are increasingly being encountered in dental practice. Current methods of medical risk assessment can however be problematic. This paper represents a multi-speciality consensus on how to identify patients that may be more at risk of an adverse cardiac event occurring perio-operatively i.e. during or in the first few weeks after a dental procedure. Drawing on guidelines for surgery and the available literature, we present on an algorithm which aims to inform dental practitioners' decisions about which patients can be managed in primary care and which should be considered for assessment by a dental specialist together with a methodology thereof.

Introduction

In recent years, fresh questions have arisen about the risk of adverse cardiac events in patients undergoing invasive dental treatment.[1] These have been prompted by case series findings of higher levels of myocardial infarction (MI) or stroke associated with dental extractions and periodontal treatment than have previously been assumed. In a self-controlled population-based series, Minassian[2] reported a 1.5 incidence ratio, ie a 50% increase, in the incidence of ischemic stroke or MI in the first 4 weeks after invasive dental treatment compared to the incidence in all other observed time periods. In a less methodologically robust study, Spivakovsky[3] reported on a cohort of 548 patients followed for 30 years where the odds of MI were 70% higher in patients who had undergone extractions of infected teeth

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compared to controls matched only by age. In a series of 200 patients scheduled for cardiac valve surgery who underwent dental extractions, Smith et al.[4] reported that 8% experienced major cardiac events or stroke.

One possible mechanism has been suggested by empirical studies which have found evidence of elevated biomarkers of systemic inflammation, coagulation and endothelial dysfunction following invasive dental treatment.[5–7] Another possible contributory factor is the role of psychological stress in triggering acute cardiac events.[8–10] Although the stress response to dental extractions is thought to be largely within the normal physiological range,[11,12] some studies of patients with cardiac disease undergoing extractions have found adverse cardiac events occurring as a result of the anxiety induced sympathetic response.[13–15]

The clinical significance of this evidence is unclear, yet dentists need a method of identifying patients with heart disease who may be more at risk of a cardiac event such as ischaemia or arrhythmia occurring either during treatment or in the immediate postoperative period. There are two main reasons.

Firstly, ischaemic heart disease, heart failure and related co-morbidities, chiefly obesity and diabetes, are being encountered more frequently in UK dental practice because of their prevalence and the ageing of the population.

Angina is experienced by 8.8% of men and 4.7% of women aged 65–74, rising to 17% of men and 11.2% of women in the 75+ age group.[16] Heart failure is present in 1–2% of the population in developed countries, rising to around 10% in those aged over 70.[17] The proportion of adults in England with obesity rose from 14.9% in 1993 to 26.9% in 2015.[18] Also the proportion of the UK population with diabetes was 6% in 2016, a rise of 65% over the last decade.[19] While the overall incidence of all types of medical events in patients attending general dental practices is low at 0.7 per dentist per year,[20,21] recent figures on '999' ambulance calls from practices in the West Midlands 2012–17 show that the most common reason was chest pain (12.4%), followed by fainting, falls and minor medical ailments (12.2%, 12.2% and 11.9% respectively). Cardiac arrest was 0.85%.[22]

Secondly the medical assessment of dental patients is sometimes suboptimal. One example is a study that found large proportions, mainly those with heart disease, being referred inappropriately by general dental practitioners to hospital oral surgery services where the treatment they required was deemed suitable to be provided by junior members of staff.[23]

Medical risk assessment methodology

The conventional wisdom in dentistry is that medical risk assessment should be based on the American Society of Anesthesiologists (ASA) scale,[24] and if in doubt, advice should be sought from the patient's medical practitioner. Both these precepts have practical difficulties. In dental practice the ASA scale has been found to be poorly understood and inconsistently applied,[25] and in medical practice it has been found to achieve only moderate inter-rater grading consistency in groups of physicians and anaesthetists.[26–28] The application of grade 3 in particular can be challenging ('moderate to severe systemic disease that is not incapacitating but may alter daily activity').

Unfortunately, liaison with medical colleagues does not always yield the information required for medical risk assessment. It may be hindered by delays in correspondence, difficulty with recalling notes, and the fact that some patients have not been seen for a long time. It is also our experience that some doctors especially GPs, decline to provide advice about the management of medical aspects of dental procedures.[29]

Little *et al.* have stated three main determinants as the basis for medical risk assessment in dentistry, namely the nature, severity and stability of the patient's medical condition, their functional capacity and emotional status (degree of anxiety), and the invasiveness of the procedure.[30] In order to elucidate these factors they advocate using the clinical predictors of cardiac risk identified in the American guidelines on perioperative cardiovascular evaluation of patients undergoing non-cardiac surgery,[31] a document which has recently been updated with a similar European version now available.[32]

These guideline documents are, however, designed for major surgical procedures carried out under general anaesthesia in hospital. Much of the evidence on which they are based is not directly applicable to minor surgical procedures under local anaesthesia, such as dental, which are classified in the 'low risk' category (risk of a major adverse cardiac event [MACE] of <1%). Also they have a level of complexity that makes them difficult to apply by nonmedical practitioners and do not account for risk factors other than cardiac (including respiratory and haematological disease), obesity and anxiety, all of which can be clinically significant. Furthermore, most dentistry is provided in a primary care setting, by clinicians few of whom have a medical qualification, and within a societal context where no amount of

associated morbidity or mortality is publicly acceptable. The threshold of what can be considered as acceptable medical risk is therefore lower in dentistry.

Nevertheless these surgical guidelines are useful in that they reiterate the three determinants identified by Little as fundamental principles. Also the stepwise algorithmic approach they take provides a means of structuring and weighing multiple pieces of information which aids clinical decision making. This paper aims to provide a simplified algorithm derived from these documents and applied to dentistry which it is hoped will facilitate basic cardiac risk assessment by dentists.

Application of the algorithm

The purpose of our algorithm (Fig. 1) is to assess which patients may be more at risk of adverse cardiac events occurring during a dental procedure as part of the information required for risk management. It is not intended to be prescriptive about which management options should be used, such as sedation; these aspects are extensively covered elsewhere.[30,33,34]

When using the algorithm for individual patients, discussion with that person and the use of clinical judgement, intuition and experience are indispensable. It is also acknowledged that practitioners have varying degrees of expertise in managing medically compromised patients and the decision as to whether it is safe for a practitioner to treat a patient depends not only on their experience, but also on qualifications and the environment in which treatment is carried out.[35] Practitioners are required in this as in any other field of practice, to be aware of and work within the boundaries of their competence and refer appropriately.[36] In patients whose cardiac condition is poorly controlled or who have multiple risk factors, information and advice from a relevant medical specialist(s) should be sought and in the more complex cases, the expertise of an anaesthetist with a preoperative risk assessment remit is invaluable.

Step 1: Is the cardiac condition unstable?

Unstable cardiac conditions are identified from the descriptors listed below. Patients with these conditions are usually unwell and are either currently hospitalised or have been admitted or attended the accident and emergency department in recent months. They

do not usually present for dental treatment but if they do, elective treatment should be deferred. However, acute dental symptoms such as severe dental pain or cellulitis should be promptly treated in a hospital-based setting in liaison with their physician/cardiologist because these may exacerbate cardiac risk if left untreated.

The essential features are as follows:
- Unstable angina is central chest pain which occurs at rest, at night, or is of new onset or increasing frequency
- Acute heart failure involves severe breathlessness usually requiring hospital admission and is often accompanied by orthopnoea (breathlessness when lying flat), tachypnoea (abnormally rapid breathing) and tachycardia (rapid heart rate)
- Significant cardiac arrhythmias are those which involve syncope and/or where the patient has an implanted defibrillator
- Symptomatic valve disease is that where as well as severe breathlessness, syncope occurs and there may be peripheral cyanosis
- Confirmed myocardial infarction occurring within the last 60 days.[31]

Step 2: Evaluate cardiac risk factors and relevant co-morbidities

Dental patients are much more likely to present for treatment with cardiac conditions that are stable but with varying degrees of control. The presence of multiple factors from the Revised Cardiac Risk Index[37] or single factors that are poorly controlled indicate increased cardiac risk. This is increased by the presence of relevant co-morbidities.

1. Ischaemic heart disease

Ischaemic heart disease is substantiated by a confirmed diagnosis by a cardiologist of angina, previous myocardial infarction (MI) or treatment involving coronary bypass surgery or stent placement. Chest pain is the cardinal symptom experienced by patients and its relationship with functional capacity in step 3 of the algorithm indicates the severity and control of the condition. The threshold for evaluating control is whether chest pain is triggered by climbing one flight of stairs 'in normal conditions and at a normal pace'. A positive answer to this indicates poor control as denoted by Class III of the Canadian Coronary scale (CCS),[38] a widely used classification of angina (see Box S1 in the online supplementary material associated with this manuscript).

When evaluating angina, it should be borne

in mind that chest pain can be an unreliable indicator as there are other common causes mainly gastric reflux and musculo-skeletal. Classically angina is characterised as central chest pain, provoked by exertion and relieved by rest or GTN. However the experience and reporting of symptoms varies greatly among patients; some may have ischemia which is silent, for example those with hypertension, advanced age or diabetes. Also medications including nitrates, nicorandil or ivabradine may be being taken but may have been pre-scribed without specialist investigation and diagnosis. Similarly, beta blockers and calcium channel blockers may be being used but pre-scribed for other primary reasons such as hypertension.[39]
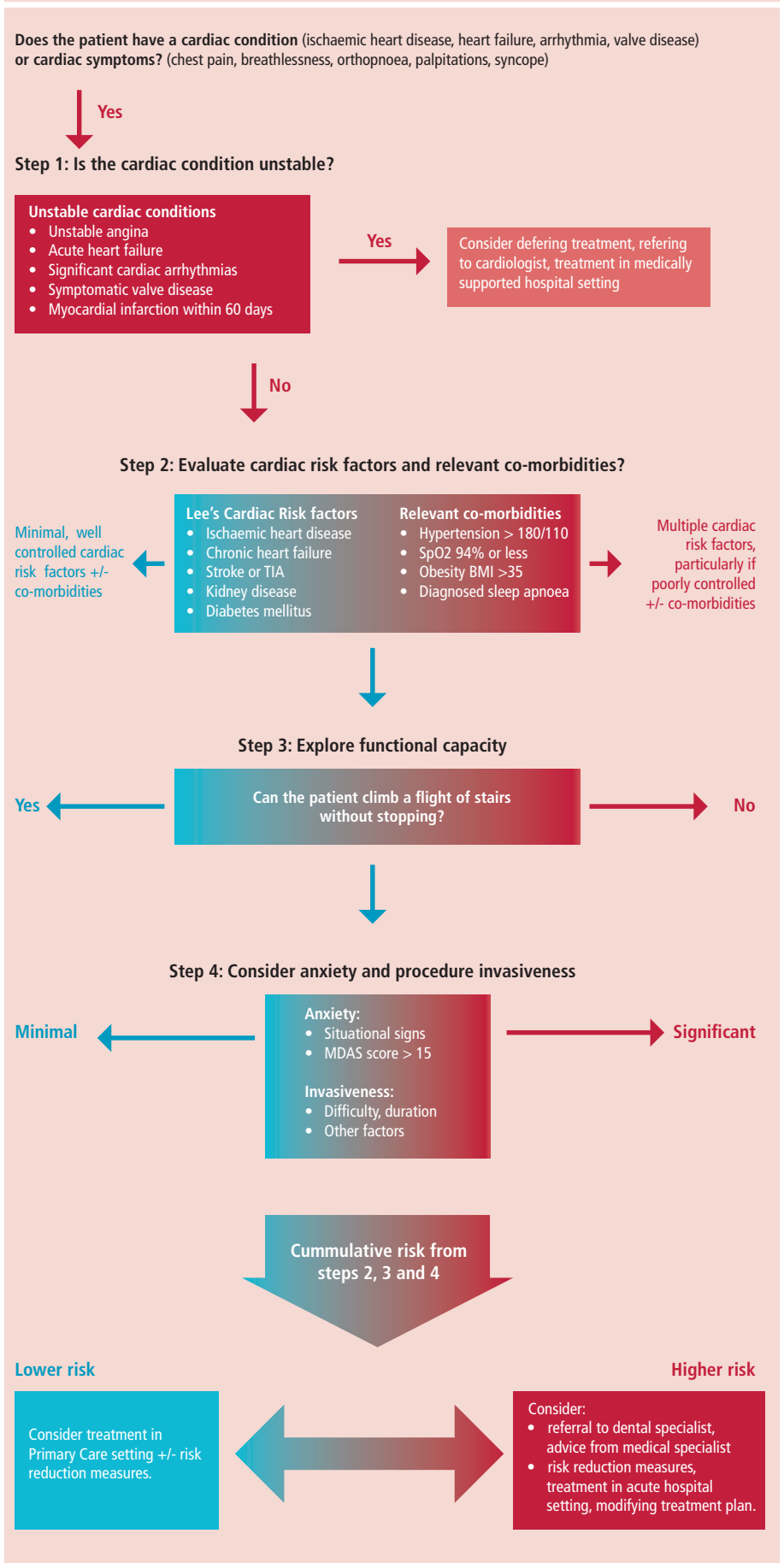
Regarding a recent MI, although the risk of a further MI occurring perioperatively during major surgery declines rapidly after 60 days, the risk of perioperative MI or stroke remains heightened for 6 months.[31] This may not apply to dental patients however, with some authors advocating that most can safely undergo necessary treatment after 6 weeks providing proper precautions are taken.[40,41] This was borne out by one study of 2,035 patients who experienced an initial MI or stroke, then a subsequent vascular event (n = 445) and underwent invasive dental treatment within 30, 60, 90 or 180 days of the first one. No asso-ciation was found between dental procedures including invasive ones, and patients' risk of experiencing a second vascular event across any of the periods examined.[42]

2. Heart failure

Heart failure is a syndrome with classic symptoms of breathlessness, peripheral ooedema and orthopnoea. Fatigue and palpitations may occur but are less reliable symptoms. Similarly to angina, the relationship of these symptoms with the patient's functional capacity in step 3 of the algorithm indicates severity and control. The standard method of evaluating heart failure is the New York Heart Association classification (NYHA)[43] (see Box S2 in the online supplementary material), and the threshold for poor control (Class III) is commonly taken as the inability to climb a flight of stairs without stopping.

Again when evaluating heart failure, it should be remembered that the typical symptoms may have a number of non-cardiac causes including respiratory, circulatory or other. A diagnosis of reduced heart function by a cardiologist or presence of a heart valve

Fig. 1 Cardiac risk evaluation in dental patients

Does the patient have a cardiac condition (ischaemic heart disease, heart failure, arrhythmia, valve disease) **or cardiac symptoms?** (chest pain, breathlessness, orthopnoea, palpitations, syncope)

Yes

Step 1: Is the cardiac condition unstable?

Unstable cardiac conditions
- Unstable angina
- Acute heart failure
- Significant cardiac arrhythmias
- Symptomatic valve disease
- Myocardial infarction within 60 days

Yes → Consider defering treatment, refering to cardiologist, treatment in medically supported hospital setting

No

Step 2: Evaluate cardiac risk factors and relevant co-morbidities?

Minimal, well controlled cardiac risk factors +/- co-morbidities ←

Lee's Cardiac Risk factors
- Ischaemic heart disease
- Chronic heart failure
- Stroke or TIA
- Kidney disease
- Diabetes mellitus

Relevant co-morbidities
- Hypertension > 180/110
- SpO2 94% or less
- Obesity BMI >35
- Diagnosed sleep apnoea

→ Multiple cardiac risk factors, particularly if poorly controlled +/- co-morbidities

Step 3: Explore functional capacity

Yes ← **Can the patient climb a flight of stairs without stopping?** → **No**

Step 4: Consider anxiety and procedure invasiveness

Minimal ←

Anxiety:
- Situational signs
- MDAS score > 15

Invasiveness:
- Difficulty, duration
- Other factors

→ **Significant**

Cummulative risk from steps 2, 3 and 4

Lower risk — Consider treatment in Primary Care setting +/- risk reduction measures.

Higher risk — Consider:
- referral to dental specialist, advice from medical specialist
- risk reduction measures, treatment in acute hospital setting, modifying treatment plan.

condition which limits mobility are the most reliable indicators.

3. Stroke and transient ischaemic attack

Stroke and transient ischaemic attack (TIA) are characterised by episodes of unilateral paralysis and/or speech disturbance which may or may not be accompanied by unconsciousness. A duration of longer than 24 hours is defined as a stroke. These indicate severe cerebro-vascular disease which is strongly associated with cardiac risk. One US study found coronary heart disease present in 62% of patients who had suffered a non-fatal stroke with no previously diagnosed heart disease.[44] However the risk of recurrent stroke or a major cardiac event after a TIA or stroke has reduced in the last decade due to the implementation of rapid management in specialised units with early instigation of anti-thrombotic therapy. Previous rates of 12–20% within 3 months have now reduced to 6.2% for MACE, and 5.1% for recurrent stroke within 12 months.[45]

4. Kidney disease

Kidney disease has multiple nonspecific symptoms. It is staged using the glomerular filtration rate (GFR), a calculation derived from the patient's serum creatinine level, their age, gender and race (see Box S3 in the online supplementary material). Those with advanced stages of the disease (stages 4 and 5) will be under the care of a nephrologist and be on dialysis and/or planned for a kidney transplant. The risk of adverse cardiac events and mortality in these patients has been shown to be closely associated with decreasing GFR and rises sharply when the GFR falls below 45.[46] They are also highly likely to have developed relevant co-morbidities including diabetes and hypertension.

5. Diabetes mellitus

Diabetes mellitus should be factored in regardless of whether it is insulin or tablet controlled because of the very high incidence of cardio-vascular disease in people with diabetes.[47] This is asymptomatic in a significant proportion.[48] The risk of major cardiac events increases with worsening control.[49] The diabetic control can be demonstrated by measuring glycosylated haemoglobin (Hb1Ac) levels in the blood where a value of more than 9% (75 mmol/mol) indicates poor control. Many diabetic patients will know their latest HbA1c level and for those who do not, an idea of their control history can be ascertained from their normal blood glucose range, any previous episodes of hypo

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Box 1 Simplified Duke Index

1 - 3 METS: Can you:

- Dress, use the toilet?
- Walk around the house indoors?
- Walk 100m on level ground without stopping?

4 -10 METS: Can you:

- Climb a flight of stairs or walk up a hill without stopping?
- Do heavy work such as moving furniture or scrubbing floors?
- Do sports like swimming, running, singles tennis, cycling?

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or hyperglycaemia and the level of involvement that has been needed from their GP or diabetes nurse.

6. Relevant co-morbidities

Relevant co-morbidities need to be taken into account in addition to any of the above risk factors. A blood pressure of 180/110 or above,[50] an oxygen saturation of 94% or below,[51] airway obstruction confirmed by diagnosis of sleep apnoea, and obesity with a BMI of over 35 are all independently associated with adverse cardiac events, and multiply the risk.[52]

Step 3: Explore functional capacity

The patient's capacity for physical exertion should be explored in further detail using the Duke Activity Status Index. This is based on metabolic equivalents (METS) where 1 MET equates to the basal oxygen consumption of a 40-year-old, 70 kg man.[53] Box 1 shows a version of the Duke Index simplified for use in the clinical setting.

A cardiac-stable patient with a functional capacity of more than 4 METs is low risk. In contrast, the inability to climb a flight of stairs (4 METs) is significant because it is independently associated with major cardiac events occurring at the time of major non-cardiac surgery,[54,55] as well as predicting future cardiac events that are unrelated to surgery.[56] While this does not equate with minor procedures such as dentistry, it still represents poor cardio-respiratory reserve which should be considered in the light of the other steps of the algorithm. An additional consideration is that these patients have a low level of physical activity which may mask cardiac symptoms as ischaemia is rarely provoked.

The functional capacity of patients with physical disability or who are wheelchair users due to musculo-skeletal conditions, COPD or obesity cannot be assessed without echocardiography, stress echo and cardiopulmonary exercise testing. For the purposes of the

algorithm, they should be assumed as having a MET capacity of less than 3.

Step 4: Consider anxiety and procedure invasiveness

Anxiety associated with dental procedures is common and has particular significance in patients with compromised cardio-respiratory reserve.

Situational signs of anxiety may include:

- Sweating, tremor, inability to speak
- Sleep disturbance, vomiting before the appointment
- Elevated BP >140/100, elevated pulse >110
- A diagnosis of generalised anxiety, depression, or recent major life events
- Acute presentation with severe pain.

In addition, the Modified Dental Anxiety Scale (MDAS, within Box S4 in the online supplementary material) may be useful, especially in patients who are stoical and do not like to admit to their anxiety. It scores the answers to the following five questions on a scale of 1–5 (not anxious, slightly anxious, fairly anxious, very anxious, extremely anxious), where a total score of 15 or more indicates severe anxiety.[57]

Indications of procedural invasiveness include the extent such as size of the surgical wound, the number of teeth involved, and the level of physical stimulus involved. Examples of the more invasive ones are:

- Extractions requiring bone removal, sectioning/decoronation, immobile teeth with dense bone
- Multiple extractions of non-mobile teeth, partial or full clearances
- Implant placement
- Extensive soft tissue surgery
- Periodontal procedures such as extensive subgingival ultrasonic scaling or periodontal surgery
- Duration of more than 40 mins
- Other operating difficulties: eg. restricted

oral access, spinal pain.

Application of the algorithm in individual cases

Lower risk patients are those whose cardiac condition is stable, with well controlled cardiac risk factor(s), no related co-morbidities, a functional capacity of 4 METS or more, who are not unduly anxious and require a procedure of low invasiveness. These can be safely managed in primary care.

Higher risk patients are those with poorly controlled cardiac risk factors, related co-morbidities, less than 4 MET functional capacity, with a significant degree of anxiety, requiring an invasive procedure. These should be referred for medical risk assessment by a specialist in special care dentistry or oral surgery as appropriate to the nature of their dental treatment need. Further advice and assessment may then need to be sought from a medical specialist, and in the more complex cases from an anaesthetist. As stated above, the management of these patients depends on the practitioner's experience, qualifications and the setting in which treatment is carried out. In doing so use of the following risk reduction measures are worth considering:

- Non pharmacological methods of stress reduction: rapport building, desensitisation, cognitive behavioural therapy
- Stress reduction protocol, judicious use of local anaesthetic and continuous monitoring of vital signs[30]
- Elective use of conscious sedation: oral benzodiazepine premedication, relative analgesia, intravenous midazolam[58]
- Use of a medically supported setting with facilities equivalent to an acute hospital
- Anaesthetist involvement.

Also in higher risk patients, the dental treatment plan may require modification when weighed against cardiac risk. This may require negotiation with the patient in terms of their expectations and helping them to accept a realistic treatment option. The range of such options includes, in ascending order:

1. Defer treatment or avoid it altogether
2. Relief of acute symptoms: pulp extirpation, drainage, analgesics, antibiotics, extraction
3. Stabilisation of caries and/or periodontal disease
4. Prioritising treatment to anterior teeth in a shortened dental arch approach and leaving symptomless posterior teeth/roots *in situ*
5. All usual treatment including restorations,

periodontal treatment and elective extractions of unrestorable teeth
6. Advanced procedures such as multiple crowns, fixed bridgework, molar endodontics, periodontal surgery, or implants.

Conclusion

With the recent development of more sensitive biomarkers and imaging techniques that can detect very small amounts of myocardial injury, further evidence may emerge to define the clinical significance of the cardiac response to dental procedures.[59] In the meantime, we have presented an algorithm designed to provide a method of identifying patients who may have higher levels of cardiac risk in order to address a scenario that is increasingly encountered by dentists due to the increasing prevalence of cardiac disease and related co-morbidities in the population. It is hoped this will not only enable adverse events to be dealt with more appropriately in secondary care when they do occur, but will also reduce their incidence by flagging up the need for preventive measures to be taken.

Our next step is to test whether we have achieved our aim by carrying out a pilot study with practitioners working in primary care and specialist practice. There are obvious similarities between our algorithm, the CCS, NHYA and ASA scales and it will be interesting to see whether the more detailed approach we have taken to evaluating severity and control of the cardiac status in relation to the patient's capacity for physical exertion, will prove this to be a more useable tool in practice.

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