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Continuous ECG monitoring in hospital: part 1, indications

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Abstract

Continuous monitoring of the electrocardiogram (ECG) is a common intervention in people admitted to hospital, especially when the cause of admission has a cardiovascular origin. Although widely considered a simple, routine procedure, ECG monitoring requires expert knowledge and sound clinical judgement for it to be used safely. Incorrect use of monitoring equipment can result in suboptimal care, and adverse patient outcomes, including death. Patient selection, correct set-up of equipment, and careful alarm management are all important in ensuring that monitoring is conducted safely. In this article, the first of two, the indications for monitoring are discussed and evaluated. For most patients, this will be arrhythmia monitoring; however, some will have an additional requirement for ischaemia or QT interval monitoring. The practical aspects of ECG monitoring will be addressed in the second article in this series.

Introduction

Continuous monitoring of the electrocardiogram (ECG) is a common intervention in people admitted to hospital for a planned cardiac procedure, or with a cardiovascular emergency (Adam et al, 2017). Although widely considered a simple, routine procedure, ECG monitoring requires expert knowledge and sound clinical judgement for it to be used safely (Hatchett, 2017). Incorrect use of monitoring equipment can result in suboptimal care, and adverse patient outcomes (Spratt, 2016). Deaths resulting from poor monitoring practice have been reported (Pelter and Drew, 2015).

Nurses are the health care workers most often responsible for initiating and managing patient monitoring; a sound knowledge of this area of practice is therefore essential. Nurses must be able to assess monitoring needs, place electrodes correctly, and manage monitor setup and alarms (Sandau and Smith, 2009). They must also decide which of the various monitoring types to initiate; for most patients this will be simple arrhythmia detection, but in some cases, there will be an additional indication for ischaemia or QT interval monitoring (Sangkachand et al, 2011). Duration of monitoring must be appropriate, and unnecessary monitoring avoided (Sandau et al, 2017).

This is the first of two articles evaluating the core knowledge that nurses need to manage continuous ECG monitoring safely and effectively. In this first article, the various indications for

monitoring are discussed and evaluated. In the second article, practical issues relating to electrode placement and lead selection will be examined, as well as the issues surrounding alarm management. Readers should note that ECG interpretation is beyond the scope of these articles, and will not be discussed.

Arrhythmia detection

The most common indication for continuous ECG monitoring is arrhythmia detection (Sandau et al, 2017). Arrhythmias are common in the acutely unwell, and have varying consequences (Bennett, 2013). Supraventricular arrhythmias, such as atrial fibrillation, often complicate cardiac admissions, causing haemodynamic instability and delaying recovery (Kirchof et al, 2016). While rarely life-threatening, early recognition allows timely treatment and improves patient outcomes (Pitcher and Nolan, 2015). In contrast, atrioventricular (AV) blocks and ventricular arrhythmias often have more serious sequalae (Adam et al, 2017). These arrhythmias are common complications of cardiac events, in particular acute coronary syndromes (ACS), and are a leading cause of death in this context (Hreybe and Saba, 2009). Early detection facilitates life saving measures such as defibrillation, one of the few interventions shown to improve outcomes after cardiac arrest (Resuscitation Council UK, 2016). Table 1 lists the most common indications for arrhythmia monitoring in patients admitted to cardiac units and wards, and is taken from recently published practice guidelines (Sandau et al, 2017). Most indications for arrhythmia monitoring are given a class I rating by the guidelines, the highest level of recommendation.

Given the importance of arrhythmia detection, it might be tempting to monitor every patient, regardless of perceived risk. Unfortunately, this is neither practical nor desirable. Outside of critical care areas, there are insufficient resources to monitor every patient. Unnecessary monitoring may result in inappropriate resource allocation; high risk patients may be denied monitoring if all available equipment is in use (Funk et al, 2010). Unnecessary ECG monitoring may also be detrimental to the patient monitored. Unless telemetry is available, ECG monitoring restricts patient movement, and ability to mobilise. This increases the risk of immobility related complications such as chest infection and pressure damage (Allen et al, 1999). Monitoring may also cause the patient anxiety, especially when a good rationale for its use cannot be given (Hatchett, 2017). According to Sandau et (2017), situations where routine arrhythmia monitoring is not indicated include: -

- Low risk and non-cardiac chest pain
- After non-urgent primary coronary intervention (PCI), without complications
- After routine diagnostic coronary angiography
- Chronic, rate controlled atrial fibrillation
- Asymptomatic sinus bradycardia
- Wenckebach AV block without symptoms, or transient AV block due to vagal stimulation.
- Patients with an existing pacemaker, implantable cardioverter defibrillator (ICD), or wearable cardiac defibrillator, admitted for an unrelated cause

Patient population	Duration / notes
Class I: monitoring should be performed	
Intermediate to high risk suspected ACS, or confirmed STEMI	At least 24-48 hours, or until ACS ruled out. See below for post-revascularisation guidance.
After MI, with successful revascularisation	At least 12-24 hours
After MI, without reperfusion or revascularization	At least 24-48 hours, and until no further evidence of ongoing modifiable ischaemia or electrical instability
Vasospastic angina	Until symptoms resolved
Apical ballooning syndrome	Until symptoms resolved
Newly diagnosed, critical left main stem lesion	Until revascularized
After open heart surgery	At least 48-72 hours in uncomplicated cases. Duration of admission if high risk of post-operative AF (e.g. elderly, left atrial enlargement, mitral valve disease, heart failure, hypertension, history of AF)
Transcatheter structural interventions	Depends on procedure, device and patient factors. At least 3 days recommended following transcatheter aortic valve implantation.
Resuscitation from cardiac arrest, or unstable ventricular arrhythmias	Until ICD implantation, or resolution of underlying cause if believed to be transient and reversible. If further in-patient therapy planned, e.g. drug initiation or ablation, continue monitoring until successful.
ICD shocks requiring hospital admission	Until the precipitating event is successfully treated.
New onset or recurrent atrial fibrillation/flutter	Until patient is haemodynamically stable following suitable treatment, for example adequate rate control or cardioversion.
Symptomatic sinus bradycardia	Until a stable heart rhythm and rate have been restored. This often requires permanent pacing unless a reversible cause is found.
Third-degree AV block, with or without symptoms.	As above.
Second-degree AV block with symptoms, or due to distal conduction system disease.	As above.
Syncope of suspected cardiac origin	At least 24 hours. Monitoring may reveal cause of syncope, e.g. asystolic pauses, AV block, ventricular arrhythmia.
After catheter ablation of cardiac arrhythmia	Depends on procedure and patient: May not be required following simple SVT ablation. 12-24 hours recommended for patients with co-morbidity undergoing complex ablation (e.g. AF, VT).
Temporary pacing	Until pacing is no longer necessary, or a permanent pacemaker is implanted.
After permanent pacemaker implantation	12 to 24 hours if no consistent, intrinsic, stable heart rhythm (e.g. underlying asystole). Consider in non-pacing dependent patient to detect early complications (e.g. lead displacement).
Acute decompensated heart failure	Until precipitating event (e.g. volume overload, ischaemia) is successfully treated.
Class IIa: monitoring is reasonable	
After non-urgent PCI, with complications	A minimum of 24 hours, or until complication is resolved
Infective endocarditis	Likely to be beneficial in patients with evidence of conduction abnormalities, heart failure, or high-risk features at echocardiogram

Table 1: Cardiac conditions requiring arrhythmia monitoring (Sandau et al, 2017)

Myocardial ischaemia

The ECG plays a key role in the diagnosis of myocardial ischaemia (Houghton and Gray, 2014). One of the most important markers of ischaemia is deviation of the ST-segment, the short section of baseline that joins the end of the QRS complex to the beginning of the T-wave (figure 1). On a normal ECG, the ST-segments are isoelectric, meaning that they sit at the same level as the other parts of the electrical baseline (especially the TP-segment) (Aehlert, 2011). During myocardial ischemia, elevation or depression of the ST-segment may occur; this information has diagnostic and prognostic significance (Morris and Brady, 2009).

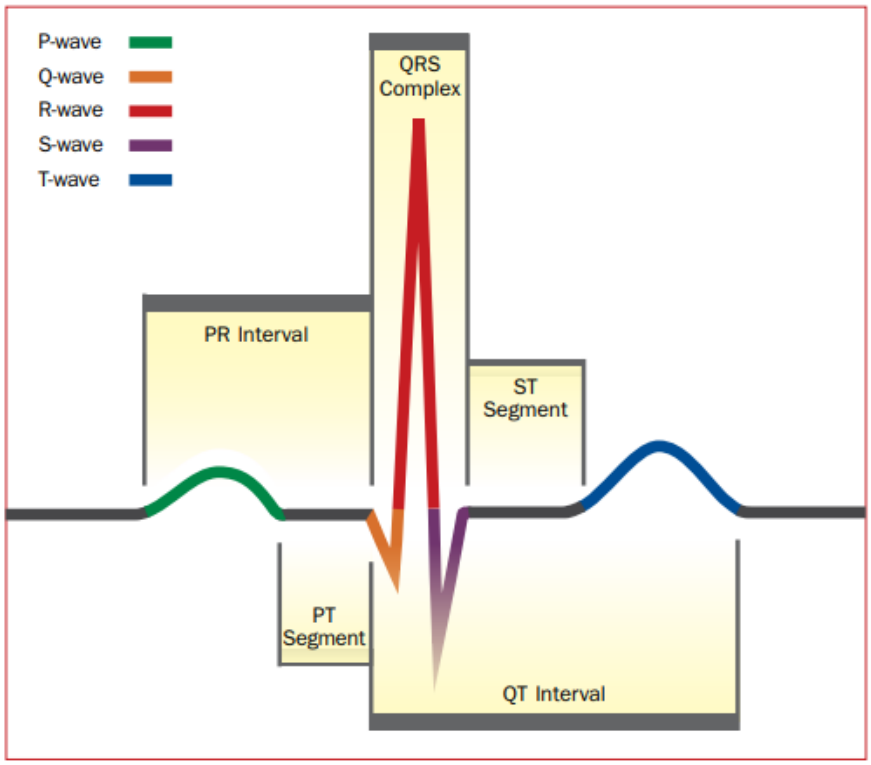

Figure 1. ECG waveforms, intervals and segments

Because sustained ischaemia can result in myocardial infarction (MI), and loss of functioning heart muscle, it is important to detect these changes early, so that treatment can be initiated (Thygesen et al, 2012). Although the 12-lead ECG is the standard diagnostic tool for the diagnosis of ischaemia, it has an important limitation; it records electrical activity for a brief moment in time only (Sangkachand et al, 2011). During an ischaemic episode, the initial ECG may be normal or non-diagnostic, and may develop diagnostic features as time elapses (Houghton and Gray, 2014). Serial 12-lead ECGs are recommended by practice guidelines to capture these changes, however between these recordings significant events may be missed (Sandau et al, 2017; Thygesen et al, 2012).

Continuous monitoring of the ST-segment is possible on many modern patient monitors, and allows real-time detection of ST depression and ST elevation (Bovino et al, 2015). This can be useful in patients admitted with suspected ischaemia, but no ECG changes, as well as situations where there is a high risk of silent ischaemia, for example in patients who are sedated and ventilated following cardiac surgery (Sangkachand et al, 2011). During non-ST-elevation ACS, the detection of ST-

segment changes can aid risk categorisation and decision making, primarily about whether to proceed with urgent coronary angiography (Carmo et al 2011).

Common indications for ST-segment monitoring are listed in table 2. Although these indications are fairly broad, ST-segment monitoring is under-used in clinical practice (Patton and Funk, 2001; Funk et al, 2010). The reasons for this include lack of awareness, scarcity of resources, and limited support from physicians. Readers will note that there are no class I indications for ST-segment monitoring; this reflects concerns about inappropriate alarms (discussed in the second article), rather than a lack of evidence for this type of monitoring (Sandau et al, 2017). As with arrhythmia detection, ST-segment monitoring is not recommended following routine angiography, uncomplicated PCI, or low-risk and non-cardiac chest pain (Sandau et al, 2017).

Patient population	Duration / notes
Class IIa: monitoring is reasonable	
Early-phase ACS for intermediate to high risk NSTEACS or ST elevation MI (STEMI)	At least 24-48 hours, or until ACS ruled out
After MI without revascularisation	At least 24-48 hours, and until no further evidence of ongoing modifiable ischaemia or electrical instability
Newly diagnosed left main coronary artery lesion	Until revascularized
Vasospastic angina	May be useful in documenting transient ST-segment changes until diagnosis confirmed and condition stable
After non-urgent PCI with complications	A minimum of 24 hours, or until complication is resolved
During open heart surgery	Duration of procedure
Class IIb: monitoring may be considered	
After MI with successful revascularisation	12-24 hours
During apical ballooning syndrome	Until symptoms resolved
During targeted temperature management	If cause of arrest thought to be myocardial ischaemia. Continue until therapy terminated.
After open heart surgery while patients are intubated and sedated	Until patient able to recognise and report symptoms of ischaemia
During acute decompensated heart failure with an ischaemia origin	Until precipitating event has been successfully treated.
In patients with acute stroke at increased risk of cardiac events	24-48 hours

Table 2. Recommendations for continuous ST-segment monitoring (Sandau et al, 2017)

Detection of QT interval prolongation

The QT interval is the time from the start of the QRS complex to the end of the T-wave, and reflects ventricular depolarisation and repolarisation (Garcia, 2015) (figure 1). Because repolarisation shortens as heart rate increases, the QT interval is shorter at higher heart rates, and longer at slower ones (Pickham and Drew, 2008). To facilitate evaluation, the interval is corrected for heart rate; the corrected QT (QTc) is a calculation of how long the QT interval would be at a heart rate of 60 beats per minute. A normal QTc is less than 450ms in men, and less than 460ms in women (Rautaharju et al, 2009). Prolongation of this interval is associated with Torsades de Pointes (TdP), a type of

polymorphic VT that can cause cardiac arrest and sudden cardiac death (Roden, 2008). Prevention of TdP is the primary rationale for QT interval monitoring; the risk of this arrhythmia increases significantly when the QTc exceeds 500ms (Bennett, 2013).

Although both depolarisation and repolarisation of the ventricles determines the QT interval, prolongation of the QTc in clinical practice is predominantly driven by delayed repolarisation. In the cardiac cell, repolarisation occurs when potassium ions leave the cell via channels in the cell membrane (Klabunde, 2012). Factors which impede normal ion movement delay repolarisation, and increase the risk of TdP. These factors include inherited diseases of cardiac ion channels, in particular Long QT Syndrome (LQTS), electrolyte imbalance, and drugs that affect ion channel function (Abrams and MacRae, 2014). Women and elderly people are more at risk, as are those with impaired kidney or liver function (Drew et al, 2010). A full list of risk factors for TdP can be found in table 3, whilst examples of drugs that prolong the QT interval are listed in table 4. Many of these are commonly used on cardiac units and wards, especially the antiarrhythmic drugs (Pickham et al, 2010). A full list of QT-prolonging drugs can be found at www.crediblemeds.org, a database maintained by the Arizona Centre for Education and Research on Therapeutics. A mobile phone app is also available from the same website.

Older age
Female gender
Structural heart disease
Bradycardia or long pauses
Hypokalaemia / hypomagnesaemia (moderate to severe)
Malnutrition electrolyte disorders
Renal or hepatic impairment
Long QT syndrome or family history of sudden cardiac death
Use of QT prolonging drugs

Table 3. Risk factors for Torsades de Pointes tachycardia (Drew et al, 2010)

Drug class	Examples
Anaesthetic	Propofol, sevoflurane
Antiarrhythmic	Amiodarone, flecainide, sotalol
Antibiotic	Azithromycin, ciprofloxacin, erythromycin
Antidepressant	Citalopram, escitalopram
Antiemetic	Domperidone, ondansetron
Antifungal	Fluconazole, pentamidine
Antimalarial	Chloroquine, halofantrine
Antipsychotic	Haloperidol, chlorpromazine
Opioid	Methadone

Table 4. Examples of drugs that prolong the QT interval (Arizona Centre for Education and Research on Therapeutics, 2017)

To reduce the risk of TdP, cardiac patients should be assessed for risk factors at admission, and the QTc should be documented. QT interval monitoring should be instigated for high risk individuals, in addition to arrhythmia monitoring (Pickham and Drew, 2008). Table 5 lists common indications for QT interval monitoring, taken from current practice guidelines. Note that QT interval monitoring is not recommended when giving non-antiarrhythmic QT-prolonging drugs if the patient has no risk factors for TdP, and no history of QT prolongation (Sandau et al, 2017). As with the ST-segment, QT interval monitoring is often under-used in clinical practice (Funk et al, 2010).

Patient population	**Duration / notes**
Class I: monitoring recommended	
Patients started on antiarrhythmic drugs with a known risk of TdP (e.g. dofetilide, ibutilide, sotalol, disopyramide, procainamide, quinidine).	48-72 hours suggested. Consider changes in QT interval, drug half-life, renal/hepatic function, presence of QT-related arrhythmias when deciding duration.
Patients with a history of prolonged QT, or with general risk factors for TdP, who are started on non-antiarrhythmic drugs with a known risk of TdP.	Consider changes in QT interval, drug half-life, renal/hepatic function, presence of QT-related arrhythmias when deciding duration.
Patients undergoing targeted temperature management	QT monitoring recommended until temperature normalised, QTc in normal range, and no QT-related arrhythmias
Patients with inherited LQTS who present with unstable ventricular arrhythmias or who have medically/metabolically induced QT prolongation	QT monitoring recommended until ventricular arrhythmias are stabilised, exacerbating medical/metabolic condition is reversed, and QTc returns to baseline.
Patients with moderate to severe hypokalaemia or hypomagnesemia who have additional risk factors for TdP	QTc monitoring is recommended until electrolytes are normalized and there is no evidence of QT-related arrhythmias
Patients with overdose of a drug known to cause TdP, or an overdose of unknown drug(s)	QTc monitoring is recommended until QT-prolonging drug levels have decreased, unknown drug has been identified as non-QT-prolonging, QTc interval is in normal range, and no evidence of QT-related arrhythmias
Class IIa: Monitoring is reasonable	
Patients with a history of prolonged QT, or with general risk factors for TdP, who are started on non-antiarrhythmic drugs with a possible risk of TdP.	Consider changes in QT interval, drug half-life, renal/hepatic function, presence of QT-related arrhythmias when deciding duration.
Class IIb: Monitoring may be considered	
Patients started on antiarrhythmic drugs with a possible risk of TdP (e.g. amiodarone, dronedarone, flecainide).	Consider changes in QT interval, drug half-life, renal/hepatic function, presence of QT-related arrhythmias when deciding duration.

Table 5. Indications for QT interval monitoring (Sandau et al, 2017)

Conclusion

ECG monitoring can be a lifesaving intervention when used appropriately, however patients must be carefully selected, and the right type of monitoring instigated. Many patients will need rhythm monitoring as arrhythmias are a common complication among cardiac patients. Other individuals will need additional assessment of the ST-segment or QTc, which tend to be under-monitored in clinical practice. Monitoring is not required in low risk patients undergoing routine procedures, and can be detrimental in these circumstances. We conclude our examination of this topic in the second part of this article, which will examine the practicalities of ECG monitoring.

Key points

- The main indication for continuous ECG monitoring is arrhythmia detection. This is a class I indication for many cardiac patients in current practice guidelines. Detection of arrhythmias can prevent clinical deterioration, and ensure timely treatment. This is especially important in arrhythmias that cause cardiac arrest, such as ventricular tachycardia.
- Some patients will also have an indication for ST-segment monitoring, in particular those with suspected ACS but no ECG changes. ST-segment monitoring is also useful in situations where there is a high risk of silent ischaemia.
- The third form of ECG monitoring is assessment of the QT interval. QT interval prolongation is common in patients admitted to cardiac units, and is a risk factor for Torsades de Pointes (TdP), and sudden cardiac death. The risk of TdP should be assessed at admission, and QT interval monitoring instigated if it is high, or if high risk medication is commenced.
- Careful patient assessment is required to determine which type of monitoring is appropriate, if any; monitoring is not required in low risk individuals undergoing routine procedures. Monitoring of the ST-segment and QT interval tend to be under-used in clinical practice.

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