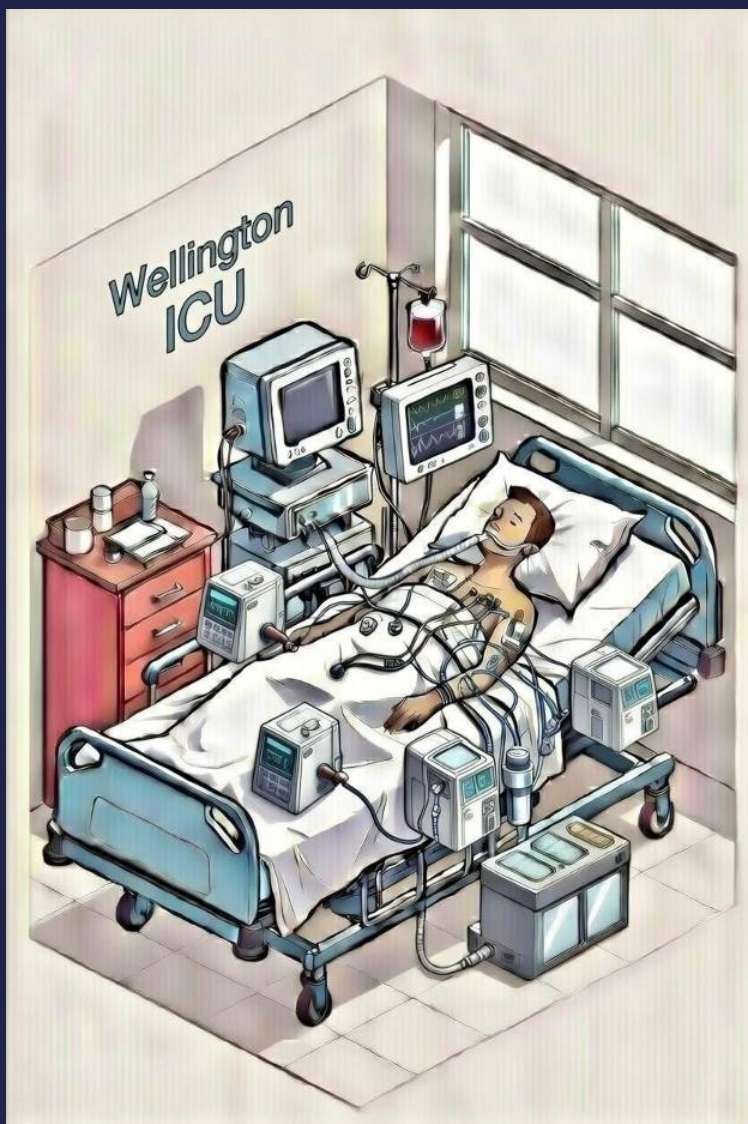


Cardiac Intensive Care

Guide for RMOs new to Wellington ICU



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Cardiac surgical patients: what is normal?

The majority of post-op cardiac surgery patients follow a predictable trajectory, are extubated a few hours after arrival to ICU and make an uncomplicated recovery. The first few hours can be busy, and these patients have specific issues that can occur and may require urgent treatment. If you are new to looking after cardiac surgical patients, it can all seem a little overwhelming. This guide aims to help you get started with your admission, and some advice from previous trainees.

Tip: If you are ever unsure or concerned about a patient, just ask for advice. Depending on the situation, this could be from a Senior Nurse, a Fellow or any of the SMOs.

Typically, even the most straightforward patient will require a few hours of observation in ICU, a bit of IV fluid, and some low dose noradrenaline, whilst we WWWE ('Warm, Wean, Wake and Extubate') them.

Some apparently 'straightforward' patients don't follow the expected trajectory unfortunately, and it can be a challenge to separate these two groups. You will receive more teaching on this during your orientation and Cardiac Advanced Life Support (CALS) course.

The boxes below are not exhaustive or applicable to every situation, but give an indication of what sort of values are 'normal' after cardiac surgery. Again, if you are concerned, particularly if things are changing rapidly it is safer to hold off waking/extubating the patient and to seek advice/investigate the cause further, such as organising a transoesophageal echo (TOE).

We also care for high risk and emergency cardiac surgical patients (e.g. pre-existing severe ventricular impairment, pulmonary hypertension, complex valve or aortic surgery). We tend to take things slower with these patients, as they are at higher risk of complications and may require prolonged levels of ICU support. Whilst you will admit these patients, and it is important that you identify these risk factors, you are not expected to make complex decisions about them. You must discuss non-routine care with the ICU Fellow/SMO also looking after them.

Reassuring post-op values:

Stable over time

$\text{FiO}_2 \leq 0.5$ for $\text{SpO}_2 \geq 92\%$
Norad < 10 ml/hr for MAP ≥ 65
CVP < 10
Lactate < 2
U/O ~ 1 ml/hr
Drain output < 100 ml/hr
Warm peripheries

Concerning findings post-op (should prompt further assessment and discussion with Senior):

Rapidly changing physiology

High drain output (> 100 - 200 ml/hr)/abrupt stop
Escalating noradrenaline > 10 - 15 ml/hr
Climbing CVP > 10 - 15
Rising lactate/new metabolic acidosis
Falling U/O < 0.5 - 1 ml/kg/hr
Brady/tachyarrhythmias or ECG changes
Unilateral weakness/focal neurology
Cold/mottled peripheries

Cardiac surgical admission:

All cardiac surgical patients will be transferred from theatre by their anaesthetic, surgical and nursing team, and will be intubated, ventilated and sedated upon arrival.

You will hear the ward clerk announce the patient's ETA and then arrival on the unit, and you should go to the bed-space to take handover from the whole team. This is a good opportunity to ask any questions about the patient, and you should make sure the primary nurse is happy & has had an opportunity to ask questions before the team leaves.

Once handover is finished, you need to do a few things:

- **Order a CXR** (check lines/ETT/drains/lung fields - see poster in fishbowl for help if needed)
- **Review bloods, ABG, 12 lead ECG** (and sign this)
- **Complete ICU pre-filled cardiac drug chart** (cross through any previous drug chart and file in notes)
 - Make sure you prescribe any additional infusions running (e.g. dopamine, milrinone) as per the [ICU drug manual](#) or patient nomogram.
 - **Tip:** It is useful to document any normal meds that you are withholding in the margins
- **Admit to WICCID** (the ICU database) and **print the admission note**

Once you have admitted your patient and reviewed post-op investigations, you should communicate your plan to the primary nurse and ensure that they are happy.

Suggested template for cardiac surgical admissions:

- **Procedure:**
 - Urgency (elective vs inpatient vs emergency)
 - Type of surgery (CABG vs valves vs aortic) and details (number of grafts, tissue vs mechanical valve etc.)
 - Indication for surgery and brief HPC including management so far/symptom severity pre-op
- **Background:**
 - Relevant PMH and SH including functional state pre-op
 - Drug history/med rec including plan for usual medications and any new inpatient meds
 - Allergies
- **Anaesthetic:**
 - Handover from anaesthetist and refer to anaesthetic chart (on SCP/printed by ward clerk)
 - Any particular difficulties/red flags
 - Any issues with: airway, line insertion, separation from bypass, pacing, bleeding/coagulopathy
 - Echo: pre- and post-op TOE usually done, what is the LV/RV function, any change/regional impairment
- **Surgical:**
 - Handover from surgeon and refer to operation note (in cardiac clinical pathway)
 - Any particular difficulties/red flags
 - Procedure details
 - Bypass/aortic cross clamp time (usually ~120 mins)
 - Drain locations
 - Post-operative instructions (antiplatelets, anticoagulation, specific BP targets etc.)
- **Clinical assessment:**
 - Check lines/tubes/drains
 - Review current infusions/supports
 - Cardiovascular assessment
 - Routine bloods/ABG/ECG/CXR
- **Plan**

Example admission note:

John Doe, 56yrs, Male, NHI: ABC1234

Procedure: Elective coronary artery bypass grafting x 2

Indication: Stable angina with complex coronary anatomy

HPC: Progressive anginal symptoms with positive exercise tolerance test 3 months ago. No prior MI/ rest pain.

Past medical history: Type 2 DM, hypertension

Social history: Lives with wife, fully independent ADLs, HGV driver, no alcohol/smoking

Drug history/med rec:

NKDA

Aspirin 100 mg OD (continue), Atorvastatin 80 mg OD (continue), Metformin 1 g BD (W/H until E+D), Lisinopril 10 mg OD (W/H), Metoprolol CR 95mg OD (W/H)

Anaesthetic

Airway: easy BMV and intubation (100% POGO), size 8.0 COETT

Lines: RIJ CVL, R radial art line, R hand 18 G PIVC; straightforward

Cardiovascular support: low dose noradrenaline only coming off pump

Echo: normal biventricular function, no valve lesion, similar post-op appearances

Blood loss/fluids/coag: EBL 1000 ml; returned 600ml cell-saved blood and 1000 ml PI148. Normal TEG.

Pacing: A+V wires, normal thresholds; native rhythm SR 50bpm; current setting AAI 88 bpm

Any specific issues?: none

Surgery

Grafts: LIMA - LAD, LRA - RCA

Drain locations: 2 x mediastinal, L pleural

CPB/XC time: 110/90 mins

Any specific issues?: none

Post-op plan: aspirin at 6hrs, aspirin/clexane/PPI day 1

On arrival to ICU

COETT size 8, 24 cm at teeth

Ventilating well FiO₂ 0.4, PEEP 5

MAP 70 on 3 ml/hr noradrenaline

HR 88 bpm AAI paced; underlying 50 bpm with drop in BP

Warm peripheries, graft sites OK

Drain sites OK; output < 100 ml/hr since return to ICU

Sedated propofol 30 ml/hr, PEARL 4mm

U/O 100 ml last 1hr

Glucose 8.5

ABG: normal gas exchange, lactate 1.5, normal BE/HCO₃

Plan:

CXR

StimPod

WWWE/Routine care

Cardiac surgical patients: the first few hours

Over the next couple of hours it is prudent to check in on the patient regularly, paying particular attention to trends in haemodynamics, vasoactive medication, drain and urine output.

Post-op shock is usually multifactorial in these patients: as stated previously, it is common for patients to become vasoplegic after bypass, and they will all have a bit of bleeding. Less common, and more subtle is cardiogenic shock, in which RV failure is often overlooked (even though it is more susceptible for a number of reasons).

Most patients will require some IV fluid post-op, with 1 - 2 litres being fairly 'normal'. Some patients will require more fluid (e.g. post AVR for severe AS, pre-op diuresis for decompensated severe MR), but this should be given in 250 - 500 ml boluses and you must reassess the patient regularly to assess their response.

Tip: for a stable patient with no high-risk features, it is reasonable to chart '250 ml PI148 PRN up to 1 litre' on the fluid chart to be used at the nurse's discretion and save you needing to repeatedly chart fluid boluses. **You must still re-assess them.**

The other main issue that can occur in this timeframe, with or without shock, is bleeding. All patients bleed a little after cardiac surgery, and the following values and actions are a useful rule of thumb:

Drain Output	Action
< 100 ml/hr	Nil; continue to monitor
100 - 200 ml/hr	Check coags and treat abnormality; usually settles down
> 200 ml/hr	Significant bleeding: inform SMO/Fellow and CTS team, aggressively treat coagulopathy/hypocalcaemia/acidaemia
> 400 ml/hr	Surgical emergency: very likely to require re-opening in theatre. Immediately inform SMO/Fellow and CTS team whilst resuscitating patient

Tip: remember that blood will pool in the chest, and a sudden 'dump' after turning can be expected, provided the patient does not have worsening shock or ongoing high drain output. Also consider that 100 ml over 15 minutes is equivalent to 400 ml/hr and should be treated the same way.

Extubation

As a rule, it is easier to manage problems in a post-op patient (e.g. bleeding, pacing issues, worsening shock) **before** extubation as we can more easily do things like TOE or return to theatre. As such it is important to thoroughly assess these patients and make sure that they are stable before proceeding to extubation.

Tip: More harm can be done by rushing to extubate a borderline patient than keeping them sedated for a little longer to ensure they are not deteriorating. **If in doubt - ask.**

In the absence of any high-risk features or complications, it is expected that most patients will be able to be woken up and extubated within a few hours after surgery. You will need to assess them at this point and be alert to any emerging complications, before making the decision to first de-sedate the patient, and then a second assessment once they are awake and decision about extubation.

It can be daunting to make these decisions if you are new to ICU. The extubation flow chart below should be used as a guide if in doubt, and always feel free to run your decision past the SMO/Fellow if you have any concerns. Patients should only be extubated out of hours if 'extubation' was on the SMO/Fellow plan from the PM ward round and there are no new issues.

Bedside nurses may request to delay extubation until after their evening handover at 7 pm. It is important that there is adequate staffing to facilitate safe extubation, and that they are able to complete other administrative/clinical tasks and to finish their shift on time. They may also have concerns that they would like to be addressed prior to extubation, and the evening ward round can be a good opportunity for this if you are unsure.

Tip: Senior Nurses are very experienced at looking after these patients: if they are worried, you should be too.

A common situation in the desedation phase is 'splinting'. This refers to a, sometimes dramatic, drop in blood pressure that occurs due to patient-ventilator dyssynchrony as a result of high intra-thoracic pressures causing reduced venous return, and sometimes bradycardia.

The treatment for this is usually to elevate the patient's legs (check for any angioseal device etc first), give a fluid bolus +/- vasopressor if prolonged. This does not represent a reason to defer extubation, but it is sensible to make sure the patient is euvolaemic, and comfortable. If pain is thought to be contributive. a small dose of analgesia may help (fentanyl is usually preferred, given as 10 - 20 mcg IV).

The actual process of extubation will usually be managed by the nursing staff, but a doctor should be immediately available. Overnight, if the unit is busy with unstable patients, or you have lots of referrals elsewhere, it may be appropriate to delay extubation until things quieten down, or to defer until the next day. Patients with a known difficult airway should not be extubated overnight.

Tip: Consider extubating to HFNP or CPAP for patients with high BMI, underlying respiratory disease, OSA/OHS — make sure you communicate this clearly to the nurse **before** you start de-sedation.

Extubation flowchart

All admissions:

- CXR (check line/ETT/drains/lung fields)
- Admission bloods, ABG, 12 lead ECG
- Complete ICU pre-filled cardiac drug chart, plus any other infusions running (and document any withheld normal meds)
- Admit to ICU database and print admission note

Any higher risk features present?

Emergency/complex surgery (double valves/aortic surgery), bad physiology (severe LV impairment, RV impairment, pulmonary hypertension, renal failure), pacing issues, intra-operative anaesthetic or surgical difficulties

If YES

D/W Senior

Any other concerns?

↓ If no, then plan is to Warm, Wean, Wake, Extubate (WWWE) after suitable observation period (usually a few hours)

Extubation assessment:

- No significant airway difficulty at induction (esp. BMV e.g. OSA/high BMI)
- $FiO_2 < 0.5$ for $SpO_2 \geq 92\%$
- CXR: no pneumothorax/large effusion, devices positioned well
- Drain outputs < 100 ml/hr, no concern for bleeding
- Achieving MAP > 65 with noradrenaline < 10 ml/hr
- No significant increase in CVP/lactate since arrival in ICU
- No sustained dysrhythmias/new ECG changes
- Urine output $\sim 0.5 - 1$ ml/kg/hr and not tailing off
- No residual neuromuscular blockade (TOF $> 90\%$)
- Normothermic

If NO

Delay +/-
D/W Senior
before
extubating

Appropriate staffing/skill mix available

Rest of unit activity OK

↓ If YES, proceed to desedation

Immediately prior to extubation:

- Spontaneously breathing, comfortable respiratory pattern with good compliance, good cough
- Awake and following commands
- Adequate muscle strength (able to lift head/arms off bed)
- No gross focal neurology
- No severe pain
- No new concerns from medical/nursing staff

If NO

Re-sedate +/-
D/W Senior
before
extubating

↓ If YES

Extubate as per ICU checklist

Pacing: basic introduction

This is a complex topic to cover in a short guide. Emergency management of temporary epicardial pacemakers will be covered in CALS, but it is worth taking a bit of time to familiarise yourself with the different modes, troubleshooting and potential complications that can arise. This [BJAEd article](#) provides a good summary. The diagram below is an illustration of the pacing boxes used in Wellington.

Modes

Pacemaker modes are named in relation to the chambers of the heart that are paced, sensed, and how the pacemaker responds when it detects (senses) the patient's native electrical activity. This is fully explained elsewhere, and to keep things simple, this table summarises the main modes that you will encounter in Wellington ICU:

Mode	Chamber paced	Chamber sensed	Response to sensed complex	Description
AAI	Atrium	Atrium	Inhibit pacing	Will deliver atrial pacing if native HR below set rate. Useful to increase HR to improve CO and maintain 'atrial kick'/physiological ventricular contraction. Relies on native A-V conduction, so not a back-up mode.
VVI	Ventricle	Ventricle	Inhibit pacing	Will deliver ventricular pacing if native HR below set rate. Most often used as a back-up if only V wires present. Can be used to increase HR as above, but lose 'atrial kick' and results in less coordinated contraction of the ventricles, so may reduce BP. Despite this, VVI is the preferred back-up pacing mode in Wellington ICU for patients who don't currently require pacing (i.e. set at a rate lower than the patient's own)
DDD	Both	Both	Dual	Requires A and V wires. Delivers atrial and/or ventricular (if ventricular conduction of the atrial impulse is not detected within set A-V interval) pacing if native HR below set rate. Benefits of preserved 'atrial kick'/physiological contraction if no A-V block.
DOO	Both	None	None	Emergency pacing mode only. Asynchronous so will pace at set rate regardless of native cardiac activity. Risk of R-on-T triggering arrhythmias.

Settings

As well as selecting a mode, the pacing box has a number of different settings that can be modified. The most important to understand are the output and sensitivity settings. Unless you are experienced in changing these, you should escalate to a senior. *The information below is provided to help understand how the pacemaker works, not necessarily for you to troubleshoot it yourself.*

The **sensitivity setting** refers to the amplitude (in mV) at which the box will recognise native complexes (sensing) - a **lower value** means that **smaller amplitude stimuli** will be sensed; a **higher value** means that only **larger amplitude stimuli** will be sensed. This has an inverse relationship to the **sensitivity threshold**, which is a measured value: the sensitivity setting at which **correct** sensing of native complexes occurs (part of pacing checks). The sensitivity setting is usually set at 50% of this threshold to ensure sensing of smaller complexes (e.g. with breathing).

The **output setting** is a more straightforward concept and refers to the current delivered with each pacing impulse (in mA). The higher the setting, the more likely capture is, but also the quicker the pacing wires will 'burn-out' & fail to work. The **capture threshold** is another measured value during pacing checks: the output setting at which reliable capture occurs. The output setting is usually set at around twice the capture threshold, again to provide a margin for change in capture threshold post-operatively (e.g. oedema)

A very **low sensitivity threshold** (i.e. pacemaker only sensing low amplitude complexes) increases the risk of **under-sensing** in which the pacemaker cannot sense smaller native complexes and may inappropriately deliver pacing (see section on troubleshooting below).

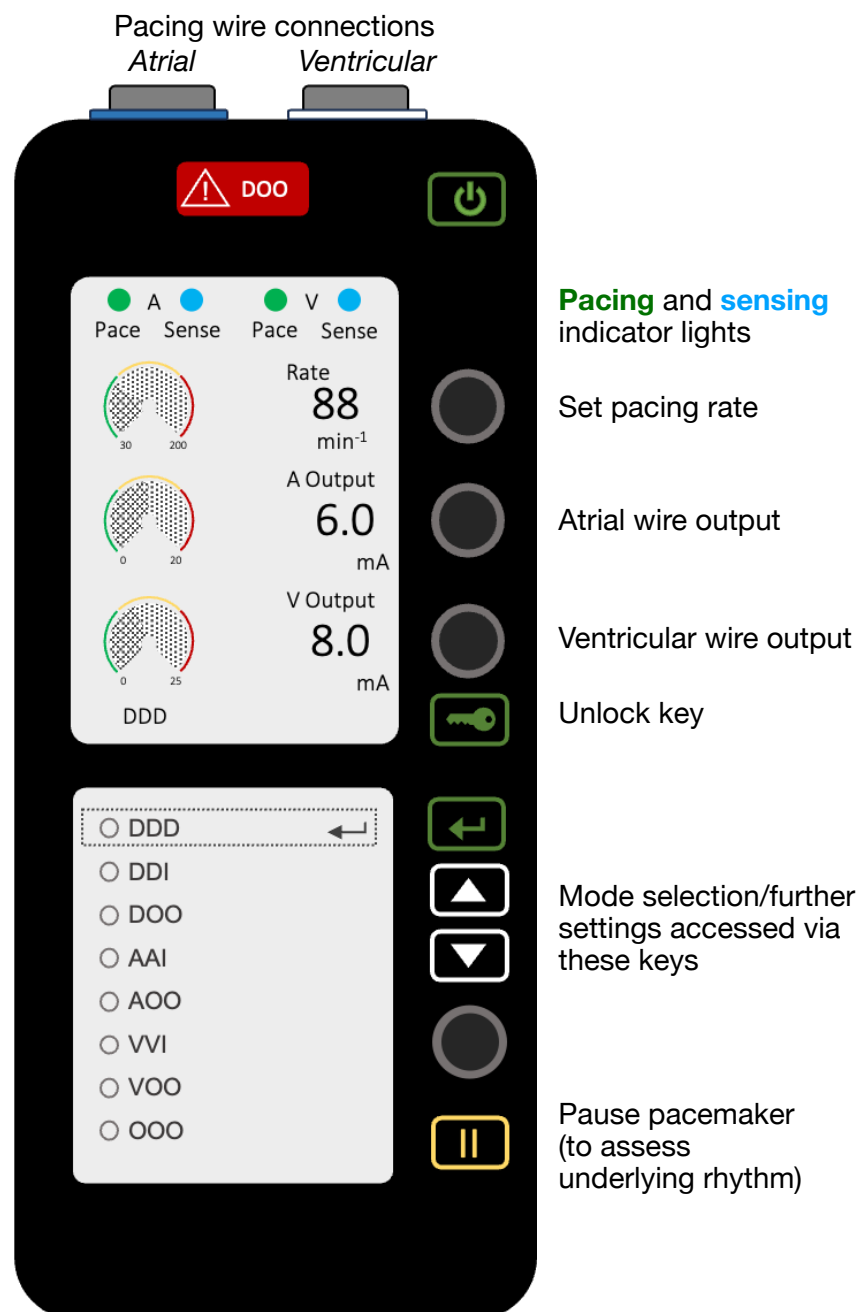
A very **high capture threshold** (e.g. wire failure, poor contact) increases risk of **failure to capture**.

There are various intervals and rate limits that can be adjusted, but leave this to the experts!

DOO Emergency button

Will deliver asynchronous pacing via both leads at maximum output when pushed

To be used initially in bradycardia emergency as part of CALS, but must return to synchronous mode (DDD) to avoid R-on-T



Pacing and **sensing** indicator lights

Set pacing rate

Atrial wire output

Ventricular wire output

Unlock key

Mode selection/further settings accessed via these keys

Pause pacemaker (to assess underlying rhythm)

Pacing: troubleshooting

The nursing staff will perform pacing checks every shift, and note the sensitivity and capture thresholds for each wire, as well as assessing the patient's native rhythm. They will ask for a review if they identify any issues.

Tip: If the patient is unstable, **call for help** and **follow CALS** principles. Otherwise take a systematic approach and assess the whole system from the pacing box to the patient to identify the cause, using the above article or similar.

The table below gives a brief description of potential pacing issues (adapted from BJAEd), and an approach to initial management.

Issue	Description	Cause	Management
Failure to pace/capture	Pacing box tries to deliver impulse	Disconnection/failure of pacing system	Pacing system check ensuring appropriate sensitivity/output setting
	Failure to pace: no pacing spike seen	Inadequate output setting, lead migration/burn out/fracture	Change pacing box/cables
	Failure to capture: pacing spike seen but no electrical/mechanical capture	Pericardial effusion Over-sensing	Transcutaneous pacing if unstable bradycardia
Inappropriate pacing	Pacing spikes occurring on-top of native rhythm	Competition with native rhythm at similar rate	Pacing system check ensuring appropriate sensitivity setting/rate
	Inhibition of pacing in absence of adequate native rhythm	Under-sensing	If very low sensitivity, should not be discharged to ward due to risk of under sensing and R-on-T
		Over-sensing	If over sensing, check for shivering/electrical interference
R-on-T induced arrhythmia	Pacing delivered during repolarisation resulting in VF/VT if ventricular or AF if atrial	Under-sensing Asynchronous pacing	CALS Pause pacemaker Defibrillation Comprehensive checks after ROSC
Pacemaker mediated tachycardia	AF with intact A-V pathway in DDD mode	Atrial arrhythmia	Pause pacemaker
	Retrograde conduction of ventricular beat is sensed as atrial activity, leading to ventricular pacing and re-entry loop	Frequent ventricular ectopy or inappropriate pacing with A-V block (allows retrograde conduction to atria) Accessory pathway	Manage as per broad-complex tachycardia if ongoing Specialist review