

**General:**

- First the atrium and then the ventricle receive a pacing spike, with the spikes separated by a programmed AV delay (simulating the delay in the AV node during an endogenous beat, and improving mechanical efficiency).  
 - There is the same risk of R-on-T VF as in the other asynchronous modes (AOO and VOO). While mechanical efficiency is better than in VOO, the ventricular spike spreads throughout the ventricle in an abnormal manner compared to that of an endogenous impulse through an intact conducting system. Mechanical efficiency of the ventricular contraction is usually less. AOO is thus preferred if the conducting system is intact.

**Indications:**

- As for VOO, but in particular in patients who derive substantial haemodynamic benefit from the contribution of atrial contraction to ventricular preload.

**General:**

- In the absence of any intrinsic cardiac depolarisation, the pacemaker behaves like a DDO. There is no sensing in the atrium. When an endogenous ventricular depolarisation is sensed (following either an atrial pacing spike or endogenous atrial depolarisation), the ventricular spike is inhibited.  
 - If a ventricular depolarisation is sensed at a time before the delivered atrial spike should have arrived, it is assumed that there has been an endogenous depolarisation in the atrium that has been conducted to the ventricle. As this endogenous rhythm is likely to be mechanically more efficient than pacing, the timing cycle is reset, delaying the next atrial spike and allowing the possibility of ongoing conducted endogenous atrial depolarisations completely inhibiting atrial and ventricular output.

**Indications:**

(i) pacemaker mediated tachycardia  
 - ventricular paced beat is conducted retrogradely up the AV node, an atrial sensing wire might interpret this as endogenous atrial activity, which in DDI and DDD modes would precipitate a release of a ventricular spike.  
 - one solution to pacemaker mediated tachycardia is to switch the pacemaker to DVI, ideally while consideration is given to a better remedy.

**Limitations:**

- atrial depolarisation might be inappropriately sensed as ventricular activity and the ventricular spike inhibited. If there is no AV conduction, there will be no ventricular contraction (cross-talk)  
 - There is a possibility that the atrial spike will not be inhibited when in fact there is an endogenous atrial rate. This may lead to competition if the atrium is beating at a faster rate, which (as in AOO etc.) can precipitate atrial fibrillation. For this reason, DDI or DDD are preferable to DVI in patients with atrial rates high enough to compete with the pacing rate.

**General:**

- DDI improves on DVI by adding atrial sensing. This prevents the possibility of the atrial pacing spike competing with an endogenous atrial rhythm. The maximum rate of delivery of pacing spikes is the same as the minimum rate set on the pulse generator. [This is the difference between DDI and DDD].  
 - The maximal rate in DDD is not the set lower rate limit; instead the ventricular pacing spikes can be delivered at a higher rate so as to 'track' atrial activity. DDI is thus better than DDD in the context of rapid atrial arrhythmias, as in DDD the ventricle will potentially be paced too rapidly.

**Indications:**

(i) As for DDD pacing, but in patients with paroxysmal atrial tachyarrhythmias.

**Limitations:**

(i) Compared to DDD, with no atrial tracking there may be no increase in pacemaker rate in the context of physiologically appropriate sinus tachycardia.

**General:**

- This is the most commonly used mode in patients with both atrial and ventricular wires.  
 - The pacemaker waits for an endogenous atrial depolarisation. If none is sensed, an atrial spike is delivered. The pacemaker then waits for an endogenous ventricular depolarisation, in response to either the atrial pacing spike or endogenous atrial depolarisation, should this have occurred. If there is no endogenous ventricular depolarisation, a ventricular pacing spike is delivered.

**Indications:**

(i) All indications for pacing, with the exception of atrial tachyarrhythmias.

**Limitations:**

(i) risk of ventricular tracking of atrial tachyarrhythmias in DDD. Most temporary pulse generators address this risk by allowing the setting of a 'maximum tracking rate'  
 (ii) pacemaker mediated endless loop tachycardia  
 (iii) may not be able to assess ST changes

**General:**

- This mode is unusual amongst the dual chamber modes in that only the ventricle is paced.  
 - The pulse generator inhibits its ventricular spike in response to a sensed ventricular depolarisation. A sensed atrial depolarisation, however, triggers a ventricular spike if an endogenous ventricular depolarisation is not sensed. If there is no endogenous atrial depolarisation, a ventricular pacing spike is delivered.

**Indications:**

- The specific indication for VDD is AV node block with an intact sinus node.

- Triggered modes (VAT, AAT, DAT) are more commonly employed in permanent pacemakers in special circumstances, but are available in some temporary external pulse generators. Triggered modes prevent inappropriate inhibition from oversensing (such as with electrocautery)

**DDO (AV sequential asynchronous)**

**DVI (AV sequential; ventricular inhibited)**

**DDI (AV sequential, non-P-synchronous, with dual chamber sensing)**

**DDD (AV universal)**

**VDD (p wave synchronous)**

**dual chamber pacing modes**

**temporary pacing modes [created by Paul Young 16/10/07]**

**NBG code**

I	II	III	IV	V
Chamber paced	Chamber sensed	Response to sensing	Rate modulation	Multi site pacing
O = none	O = none	O = none	O = none	O = none
A = atrium	A = atrium	T = triggered	R = rate modulation	A = atrium
V = ventricle	V = ventricle	I = inhibited		V = ventricle
D = dual (A + V)	D = dual (A + V)	D = dual (T + I)		D = dual (A + V)

**AOO (atrial asynchronous)**

**General:**  
 - Pacing spikes are delivered to the atrium at a set rate, regardless of electrical activity in either chamber of the heart.  
 - There is a risk in asynchronous atrial pacing that a pacing spike might be delivered in the repolarisation phase of an endogenous beat, which may precipitate atrial fibrillation.  
 - The refractory period of the AV node should prevent the depolarisation from being conducted to the ventricle, which should prevent VF.  
 - Because of this risk of atrial fibrillation, use of AOO is usually restricted to stable bradycardia, where the pacemaker rate reliably exceeds the endogenous rate. If this is the case, the pacemaker spike should always occur before any endogenous impulse would have been generated.

**Indications:**  
 (i) Bradycardia with intact AV node conduction, in situations where synchronous modes are contra-indicated. [This rarely means anything other than during use of electrocautery, which can interfere with sensing.]

**Limitations:**  
 - Contra-indicated in atrial tachycardia, atrial fibrillation/ flutter (due to inability to capture the atrium), and AV node block.

**VOO (ventricular asynchronous)**

**General:**  
 - Analogous to AOO, pacing spikes are delivered to the ventricle, regardless of the endogenous electrical activity of the heart.  
 - As in the atrium, there is a risk that a ventricular pacing spike might be delivered while the ventricle is in the repolarisation phase of an endogenous beat. This is the classic 'R-on-T' phenomenon, known to precipitate VF.

**Indications:**  
 (i) Bradycardia without reliable AV node conduction, in situations where synchronous modes are contra-indicated (e.g. with electrocautery).  
 (ii) In an emergency, to preserve cardiac output in the case of malfunction of pacing in one of the more sophisticated pacemaker modes, while the cause of the malfunction is rectified. For this reason, some pulse generators have this as a 'rapid access' function.

**Limitations:**  
 - Competition with intrinsic rhythm;  
 - possibility of R-on-T VF.

**AAI (atrial demand)**

**General:**  
 - The pulse generator has a sensing 'timing cycle', which is determined by the rate set on the pacemaker. If no endogenous depolarisation is sensed by the end of this timing cycle, a pacing spike is delivered to the atrium.  
 - After an atrial depolarisation (either endogenous or a pacing spike), a pacemaker atrial refractory 'blanking' period begins, during which there is essentially no sensing at all. This is required to prevent atrial after-depolarisations resetting the timing cycle.

**Indications:**  
 - Bradycardia, with an endogenous atrial rhythm (or frequent ectopics) sufficiently quick to compete with the pacemaker rate.

**Limitations:**  
 - atrial tachycardia, atrial fibrillation / flutter (due to inability to capture the atrium), and AV node block.

**VVI (ventricular demand)**

**General:**  
 - VVI is the same as AAI, except the sensing and pacing is in the ventricle. As with VOO, during a paced beat there is no co-ordinated atrial contraction, which can significantly reduce cardiac output.

**Indications:**  
 (i) Similar to AAI, but where there is no reliable AV node conduction to the ventricle.  
 (ii) Bradycardia with AV block, sick sinus syndrome, atrial fibrillation, atrial flutter.  
 (iii) Overdrive suppression of ectopic beats.

**Limitations:**  
 - No atrial contribution to ventricular preload.  
 - AV synchronicity is lost  
 - unable to assess ST changes  
 - risk of pacemaker syndrome

**single chamber pacing modes**

**triggering**