NUMERO: 1451A - ANNO: 2015

# A P P U N T I

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MATERIA: Dispositivi Impiantabili Attivi + temi d'esame, Prof.Knaflitz

# MANUALE ICD

Catetere + ICD + programmatore = sistema globale

Tradizionale l'impianto per via transvenosa sx è consigliato. In alcuni casi per la scarica ad alta energia si usano elettrodi direttamente posti sul tessuto del miocardio. Intervento per toracoscopia o a torace aperto

La scarica a bassa energia avviene come per il sistema tradizionale, possono 2 catetere con diametri inferiori

Defibrillatori di ultima generazione: elettrodi di forma come cateteri che possono essere impiantati nel mediastino, ma non riducono la soglia con il miocardio. Non direttamente nella camera cardiaca

## Caratteristiche:

ICD identifica 3 ritmi
- fibrillazione ventricolare (la più pericolosa)
- tachicardia ventricolare (ritmo presente, scarica sincrona)
- " " veloci

e le tratta in modi differenti

fibrillazione v.: eroga un impulso bifasico con energia fino a 30 J o il ritmo viene convertito o persiste la fibrillazione, allora interviene con un altro shock. Può arrivare fino a 5 shock consecutivi (alta probabilità di conversione) → 2 minuti di fibrillazione, tempo lungo

tachicardia v.: meno pericolosa, diminuisce l'efficienza di pompa, ma non l'annulla. Intervento meno aggressivo perché la scarica di 30 J è uno shock assorbito. Si usa solo se strettamente necessario. rischio di morte
Altrimenti uso una terapia antitachicardia con il pacemaker. TERAPIE ANTITACHICARDICHE
RAMPS non sono adorate il paziente non se ne accorge. Stimolazione a bassa energia del ventricolo dx. Se non sono efficaci devo ricorrere ad uno shock di cardioversione che può arrivare anche a 30 J ma che deve essere sincronizzato.
Se non funziona shock a 30 J sincronizzato con onda R.

tachicardia intermedia: Stimolazione a basse - alte energia a seconda del paziente
tachicardia ventricolare, bisogna che nessuno come conseguenza di una tachicardia decide SVT. Non vanno trattate, alcuni dispositivi sopraventricolari non sanno distinguerle, bisogna osservare anche l'atrio. Per questo si punzecchiano i ventricolari

Scariche opportune: quando è davvero necessario, ci possono essere però anche scariche inopportune ad esempio la scarica effettuata in presenza di SVT

Scarica efficace: scarica opportuna che riesce a ripristinare il giusto ritmo sinusale. Può avere una scarica inefficace se energia non abbastanza elevata.
Se inopportuna non ha senso parlare di efficacia, può classificata solo come inopportuna
Situazione difficile quando il paziente è affetto da due tachicardie diverse: tipicamente tachicardia sopraventricolare e ventricolare

limiti dei primi 2 dispositivi: non distinguevano le due tachicardie

compito dell'ICD: rilevare correttamente tachiaritmia ventricolare
Può succedere che:
- c'è tachiaritmia ma non viene rilevata
- tachiaritmia riconosciuta quando non c'è → scarica inappropriata

Vengono ads con lo studio della tempistica → non valutano la forma del segnale ma controllano solo se c'è variazione nei cicli e negli atri

La corretta rilevazione è più importante che nell'PM: → lavoro dell'amplificatore (anche ICD)
l'ICD lavora con adattamento automatico della soglia → sulla soglia



## Details about sensing

la forma della soglia varia da impianto ad impianto!!!
NON SEGUE UNA PROGETTAZIONE TEORICA

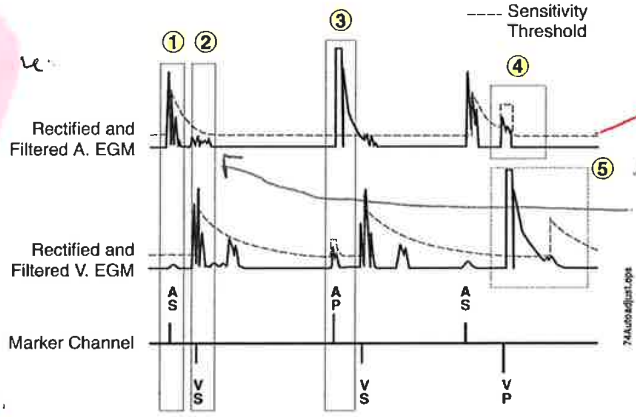
Cattivo elettrogramma atriale e ventricolare

### Auto-adjusting sensitivity thresholds

The device automatically adjusts the sensitivity thresholds after certain paced and sensed events to help reduce oversensing from T-waves, cross-chamber events, and pacing. Figure 6-2 shows how sensitivity thresholds are adjusted after different types of events.

SENSIBILITÀ ≠ SPECIFICITÀ
sono inversamente proporzionali, vorrei aver entrambe buone, la soglia nel tempo può essere variata quando so che c'è l'evento, basse quando non c'è

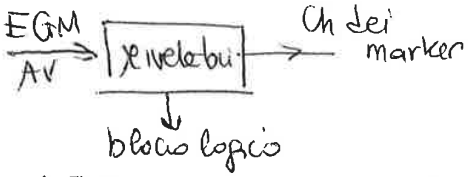
**Figure 6-2.** Auto-adjusting sensitivity thresholds




Usa i marker dei canali A. V.

2°: dati i marker decidere se c'è o meno depolarizzazione

Soluzione empirica




A SOGLIA SINGOLA: individuo un livello di soglia, poi se il segnale è sopra la soglia allora l'evento è presente, altrimenti l'evento non è presente

1 After an atrial sensed event, the atrial sensitivity threshold increases to 75% of the EGM peak (maximum: 8x the programmed value, decay constant: 200 ms).

2 After a ventricular sensed event, the ventricular sensitivity threshold increases to 75% of the EGM peak (maximum: 8x the programmed value, decay constant: 450 ms).[a]

dopo 150 ms l'onda T del ventricolo

3 After an atrial paced event, the device does not adjust the atrial sensitivity threshold. The ventricular sensitivity threshold increases by 0.45 mV (decay constant: 60 ms).[b]

STIMOLAZ. ATRIALE

4 After a ventricular paced event, the atrial sensitivity threshold increases to 4x the programmed value (maximum: 1.8 mV, immediate return after 60 ms).[b]

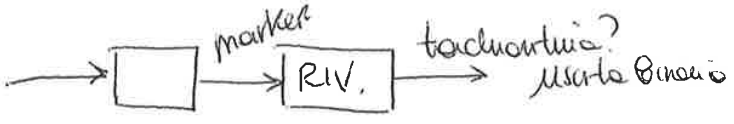
5 After the ventricular pace blanking period is finished, the ventricular threshold increases to 4.5x the programmed value (maximum: 1.8 mV, decay constant: 450 ms).

→ TERMINATO IL BLANKING VENTRICOLARE

[a] The exponential decay continues through a subsequent ventricular pacing pulse and its blanking period.

[b] If the programmed sensitivity value exceeds 0.3 mV (ventricular) or 1.2 mV (atrial), the threshold is not adjusted.






2 rivelatori in cascata uno a soglia singola l'altro a DOPPIA SOGLIA

Non ne beve! ho tanti eventi. Alta la soglia, resto al livello specifico. Questo è il punto di rilevare gli eventi che cerco senza che gli eventi errati si sono quando non ci sono

VT FVT VF

più le tachicardie sono rapide più sono pericolose

Il defibrillatore cardioverter riconosce la tachicardia etc. in base alla durata non deve fare una differenziazione findagia ma deve riconoscere un episodio di fibrillazione da un evento di ritmo

EPISODIO: l'ICD tratta l'episodio non l'evento. Se l'ent. V-V appartiene ad una delle regioni definite*

EVENTO: singolo atto cardiaco. Evento VT nel momento in cui la durata del ciclo all'interno di un intervallo all'interno del quale normalmente si classifica la tachicardia appartiene alla regione di riconoscimento, quando si' | Chapter 6 Detecting VF episodes Si dice l'evento non è detto che ci sia anche il ritmo. Ci sono tachicardie sostenute un determinato di eventi

* mi chiedo se sia un evento o no. Rivelatore a doppio soglio

## Refractory periods

During a refractory period, the device senses normally, but classifies sensed events as refractory and limits its response to these events. Pacing refractory periods prevent inappropriately sensed signals, such as far-field R-waves (ventricular events sensed in the atrium) or electrical noise, from triggering certain pacing timing intervals.

Synchronization refractory periods help prevent the device from delivering cardioversion and defibrillation therapies at inappropriate times. See "Synchronizing defibrillation without confirming VF" on page 124 and "Synchronizing cardioversion after charging" on page 145.

**Note:** Refractory periods do not affect tachyarrhythmia detection.

# Detecting VF episodes

The device detects VF episodes by examining the cardiac rhythm for short ventricular intervals. If a predetermined number of intervals occurs that are short enough to be considered VF events, the device detects VF and delivers the first programmed VF therapy. After therapy, the device continues to evaluate the ventricular rhythm to determine if the episode is ongoing.

See details about VF detection on page 78.

### Parameters

| | * Medtronic nominal setting |
|---|---|
| **VF Detection Enable** – Turns VF detection on or off. | On*, Off |
| **VF Interval** (ms) – V-V intervals shorter than this value are counted as VF events. | 240, 250, . . ., 320*, . . .,400 |
| **VF Initial NID** – Number of Intervals to Detect: number of VF events the device must count to detect a VF episode. | 12/16, 18/24*, 24/32, 30/40, 45/60, 60/80, 75/100, 90/120, 105/140, 120/160 |
| **VF Redetect NID** – Number of Intervals to Redetect: number of VF events the device must count to redetect a continuing VF after a therapy. | 6/8, 9/12, 12/16*, 18/24, 21/28, 24/32, 27/36, 30/40 |

0 - 320 ms

n° soglia / finestra complessiva

il rapporto è sempre del 75% scelta di Medtronic

NON ESISTE STRATEGIA del NID!

non è una frazione!

Se ho un episodio tachicardico, se l'episodio si è risolto non faccio una nuova scelta; se si è risolto il dispositivo usa nuovamente l'initial NID, se non si è risolto effettua sempre un controllo ma con una nuova NID, la finestra d'osservazione è più breve, normalmente la velocità



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un intervallo VV è un evento VF se la durata è ≤ al valore del limite (300-320ms) in base agli elettrogrammi endocavitari riescono gli eventi di depolarizzazione ventricolare... in realtà considera i VS

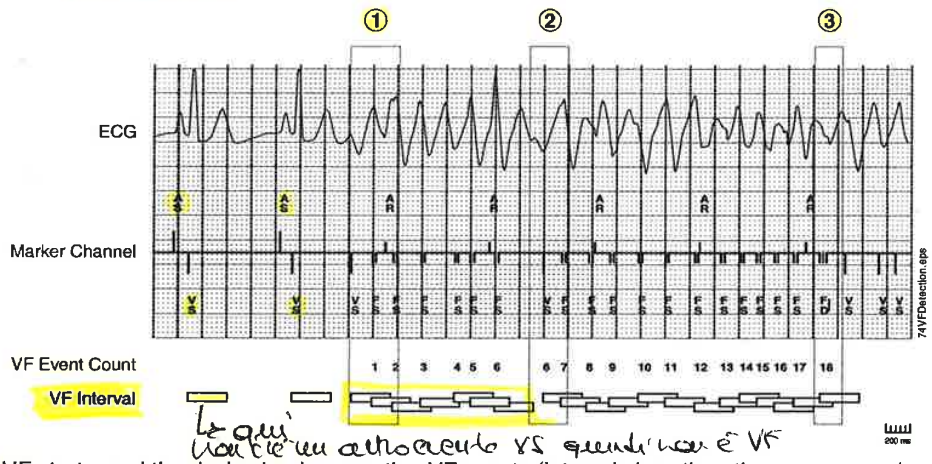


The threshold for detecting VF is the first number in the programmed VF NID (for example, 18 events if the VF Initial NID is 18/24). This threshold is always 75% of the VF detection window. That is, if 75% of the events in the VF detection window are VF events, the device detects a VF episode (see Figure 6-3).

After the device detects VF, it delivers the first programmed VF therapy. Following the therapy, if the number of VF events reaches the programmed VF Redetect NID, the device redetects VF and delivers the next programmed VF therapy.

**Note:** The device can also detect VF Episodes via the Combined Count detection criterion (see page 91).

**Figure 6-3.** Device detects VF RICONOSCIMENTO VF




Le qui c'è un altro evento VS quindi non è VF

1. VF starts, and the device begins counting VF events (intervals less than the programmed VF Interval).
2. A ventricular interval occurs outside the VF detection zone. The VF event count is not incremented.
3. The VF event count reaches the programmed VF NID value of 18 events out of 24, and the device detects VF.

Il contatore non viene incrementato se i valori (eventi) escono dall'intervallo il programmatore ha inserito un contatore del numero a doppio soglia:

24 lunghezza finestra
18 valori della soglia

## How to program VT detection


To program VT detection:

1. Select Params > Detection.
2. Select the desired values for VT Enable, VT Initial NID, VT Redetect NID, and VT Interval.
3. Select [PROGRAM].

## Details about VT detection

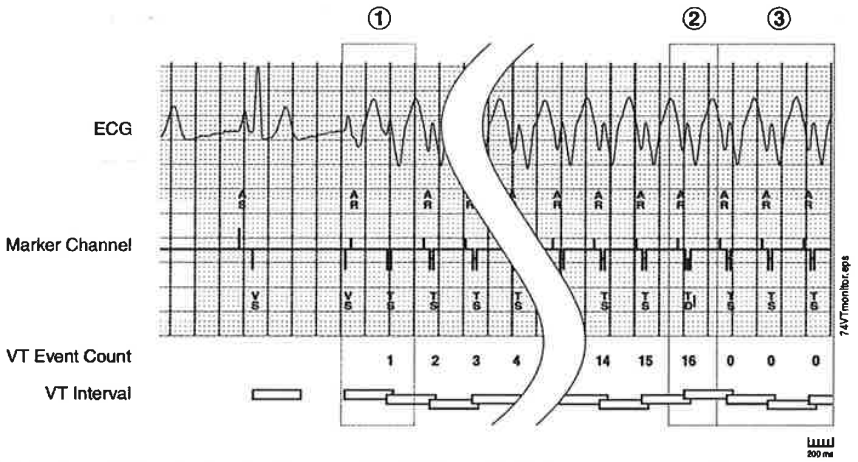
The device detects VT by counting the number of consecutive VT events. A VT event is a V-V interval shorter than the programmed VT Interval but greater than or equal to the VF Interval. If the number of consecutive VT events reaches the programmed VT Initial NID, the device detects VT (see Figure 6-4).

The VT event count resets to zero whenever an interval occurs that is greater than or equal to the programmed VT Interval. The count remains at the current value if an interval is shorter than the programmed VF Interval.

After the device detects VT, it delivers the first programmed VT therapy. Following the therapy, if the VT event counter reaches the VT Redetect NID, the device redetects VT and delivers the next programmed therapy.

**Note:** The device can also detect VT Episodes via the Combined Count detection criterion (see page 91).

**Figure 6-5.** Device detects and monitors VT




1 VT starts, and the device begins counting VT events (intervals less than the programmed VT Interval but greater than or equal to the VF Interval).

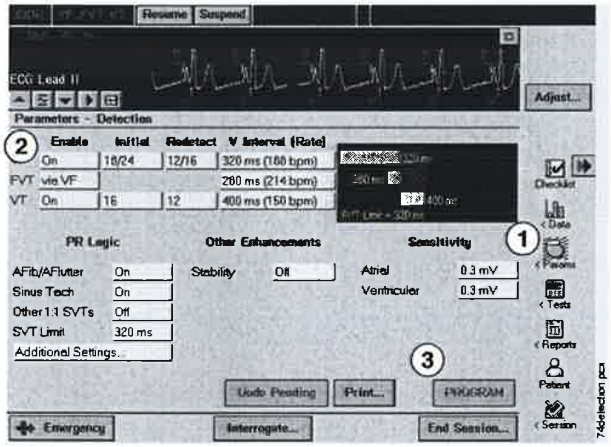
2 The VT event count reaches the programmed VT NID of 16 events, and the device detects VT.

3 After detecting the VT episode, the device resets the VT event count to zero and monitors the episode until termination.

**FVT detection** – To ensure reliable ventricular tachyarrhythmia detection, the programmer regulates the values available for the FVT parameter as follows:

- VT Detection must be set to On if FVT Detection is set to via VT.
- If FVT Detection is set to via VF, the FVT Interval must be programmed to a value shorter than the VF Interval.
- If FVT Detection is set to via VT, the FVT Interval must be programmed to a value greater than the VF Interval and less than or equal to the VT Interval.

## How to program FVT detection




To program FVT detection:

1. Select Params > Detection.
2. Select the desired values for FVT Enable and FVT Interval.
3. Select [PROGRAM].

## Details about FVT detection

You can program the device to detect FVT episodes via the VF or VT detection zone and NID.

When FVT Detection is set to via VF, a V-V interval within the FVT detection zone is marked as an "FVT via VF" event. When the VF NID is reached, the device reviews the last eight intervals:

- If any of the last eight intervals are in the VF zone, it detects the episode as VF.
- If all of the last eight intervals are outside the VF zone, it detects the episode as FVT (see Figure 6-6).

Problema dei Ritmi instabili: il ritmo tachicardico oscilla tra VF e VT
Posso ritardare o non fare un riconoscimento VF
N su N eventi cui cui valle zone VF
uso un nuovo NID → CNID



# Detecting tachyarrhythmia episodes with Combined Count

Because the device counts VF and VT events separately, rhythms with variable cycle lengths can cause both event counts to increment during an episode. To prevent these rhythms from delaying detection, the device automatically enables the Combined Count detection criterion if both VF and VT detection are programmed On.

The Combined Count criterion compares the sum of the VF and VT event counts to the Combined Number of Intervals to Detect (CNID), which the device calculates automatically from the programmed VF NID values. If the CNID is met, the device reviews the recent intervals to determine if the episode should be treated as a VF, FVT, or VT episode. The Combined Count criterion applies during both initial detection and redetection.

## Details about Combined Count detection

The Combined Count detection algorithm expedites detection or redetection of ventricular tachyarrhythmias with ventricular intervals that fluctuate between the VF and VT detection zones. When VT detection is on, the device applies Combined Count detection, which tracks the combined number of VT and VF events counted. If this sum reaches the Combined Number of Intervals to Detect (CNID), the device detects VF, FVT, or VT. Combined Count detection also applies to redetected episodes.

**Note:** Combined Count detection is off when VT detection is set to Monitor or Off.

If the VF event counter reaches six, the device automatically applies the Combined Number of Intervals to Detect (CNID). The CNID is calculated by multiplying the current VF NID (Initial or Redetect) by 7/6 and rounding down. Table 6-2 shows the CNID values that correspond to each VF NID value.

episodio termina quando il DM conteggiando 1 o più cicli osserva che non c'è più il problema. Può succedere o che la tachicardia ci sia ancora con caratteristiche simili a quella prima dell'intervento (in questo caso il DM continua con la terapia o con una nuova) oppure la tachicardia può accelerare in seguito alla scarica, aggravando così un peggio recente



Un soggetto molto sensibile è poco specifico → scariche inappropriate

Il paziente può cadere a fare togliere il dispositivo a causa delle scariche inappropriate dell'attività atriale non è ancora stata considerata!

Come fa a definire che la tachicardia è accelerata?

**VT acceleration**

If the device redetects VT, it classifies the rhythm as accelerated if the average of the four intervals before redetection is at least 60 ms less than the average of the four intervals before initial VT detection. The most recent interval average is used to identify VT acceleration if VT is redetected again during the episode.

If the device redetects VF or an accelerated VT after an antitachycardia pacing sequence delivery, it skips the subsequent pacing therapy sequences for the duration of the episode and delivers the next therapy programmed for the current arrhythmia.

## Enhancing detection with PR Logic criteria

→ deriva dalle analisi dei marcatori sia di P che di R

Aumentano la specificità senza diminuire la sensibilità

The PR Logic detection criteria are designed to withhold inappropriate ventricular detection during episodes of rapidly conducted supraventricular tachycardia (SVT). The device analyzes the activation patterns and timing in both chambers using PR Logic pattern and rate analysis. This information helps identify evidence of atrial fibrillation, atrial flutter, sinus tachycardia, and other 1:1 SVTs. If this analysis indicates the presence of one or more of these rhythms, the device withholds detection.

Individua una serie di situazioni in cui è presente la tachicardia ma che non comporta pericoli immediati al paziente

Si applicano ai tempi temporali sui marker attuali e ventricolari

For more information, see

- "Details about PR Logic pattern and rate analysis" on page 101
- "Details about the PR Logic detection criteria" on page 105

SVT: tachicardie sopraventricolari: non richiedono trattamento tramite shock ad alta energia

FIBRILLAZIONE: manca il ritmo, le fibre muscolari si contraggono a pacchetti in modo indipendente l'efficienza di pompa è zero (quella ventricolare è più pericolosa dell'atriale nelle quali i ventricoli si possono riempire grazie alla fase di gittata)

FLUTTER: contrazione velocità non fisiologica, viene mantenuto uno sincronismo atrioventricolare

La depolarizzazione parte in un punto, nel momento in cui aumenta il volume degli atri per percorrere la circonferenza in modo più lungo e arriva al punto di partenza quando è già finito il periodo refrattario

Marquis DR 7274 Reference Manual

Deriva solo dal problema atriale, non ventricolare.

Fatto la scarica ad alta energia → interrogo confermo

i dispositivi vanno guardano la morfologia del segnale

Il dispositivo analizza tramite i pattern per identificare la tachicardia del seno/flutter atriale e altre SVT. Il DVA conta quanti intervalli atriali succedono il numero di eventi atriali e le zone in cui occorrono



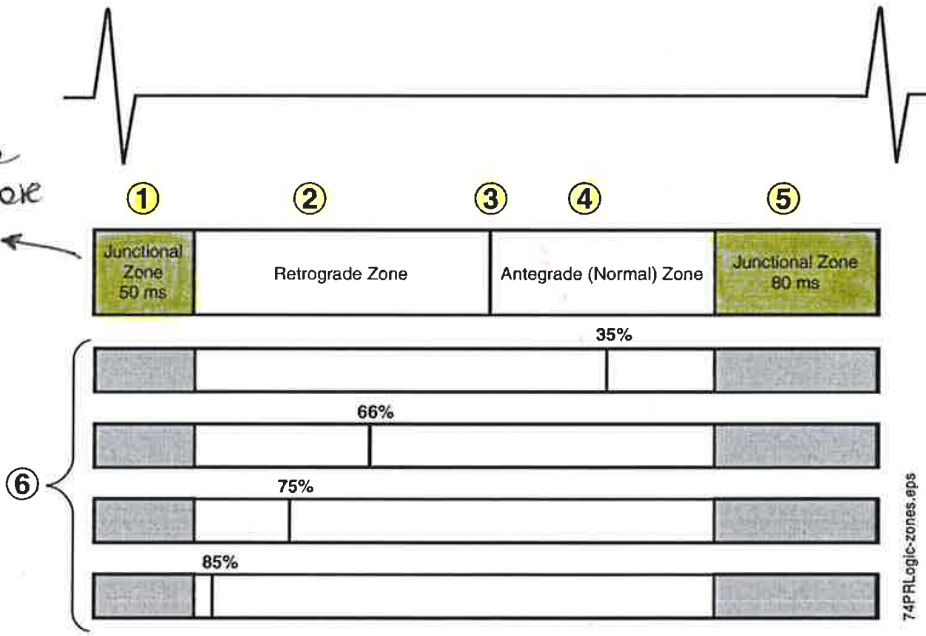
intervallo VA: gli eventi appartengono a due cicli cardiaci differenti

1-5 due cardiaci

## Pattern analysis of A-V and V-A intervals

The device uses pattern analysis to identify sinus tachycardia, atrial flutter, and other 1:1 SVTs. Within each V-V interval, the device categorizes the atrial rhythm according to the number of intervening atrial events and the zones in which those atrial events occur (see Figure 6-10). From this information, the device assigns pattern codes to the intervals, and interprets the pattern codes to identify SVTs.

**Figure 6-10.** Zones used during A-V pattern analysis




precede e segue la contrazione ventricolare nell'intorno dell'evento ventricolare

1 Atrial events in the first junctional zone indicate PAC, PVC, junctional rhythms, atrial fibrillation, or atrial flutter.

2 Atrial events in the retrograde zone indicate retrograde conduction of ventricular events.

conduzione dai V. agli atri di eventi V.

la durata dipende dal paziente

3 The 1:1 VT-ST Boundary separates the retrograde and antegrade zones. The nominal value of this boundary is 50%. fino al 50% zona retrograda, oltre anterograda

4 Atrial events in the antegrade zone indicate normal conduction (sinus rhythm, sinus tachycardia). → conduzione normale

5 Atrial events in the second junctional zone indicate PAC, PVC, junctional rhythms, atrial fibrillation, or atrial flutter. → extrasistole atriale/ventricolari

6 The 1:1 VT-ST Boundary can be programmed to different values, changing the relative size of the antegrade and retrograde zones.

1:1 VT-ST
Confine tra retrograda e anterograda

- The ventricular cycle length is not regular (regularity of 50% or less).

The atrial flutter rule is satisfied if A-V pattern information indicates atrial flutter, without far-field R-wave sensing.

### Sinus Tach criterion

The Sinus Tach criterion is met if A-V pattern analysis indicates a 1:1 sinus tachycardia without far-field R-wave sensing (with atrial events primarily in the antegrade zone shown; see Figure 6-10 on page 102).

The size and timing of the antegrade zone is dependent on the 1:1 VT-ST Boundary parameter. See "Customizing PR Logic for patients with slow conduction" on page 99.

The Sinus Tach criterion also recognizes and withholds inappropriate detection for a 1:1 sinus tachycardia when far-field R-wave oversensing occurs consistently.

### Other 1:1 SVTs criterion

The Other 1:1 SVTs criterion is satisfied when A-V pattern information indicates a 1:1 SVT in which the atria and ventricles are activated at approximately the same time, as in a junctional tachycardia (consistent atrial sensing in a junctional zone). See Figure 6-10 on page 102.

PROBLEMA delle DOPPIE TACHICARDIE:

1 SOPRAVENTRICOLARE E 1 VENTRICOLARE VERA E PROPRIA



## Detecting double tachycardias

vuol dire impedire la nucleazione di VT

To ensure proper detection and therapy during double tachycardia episodes (VT, FVT, or VF in the presence of SVT), the device provides double tachycardia detection whenever PR Logic detection criteria are enabled. The device detects double tachycardia episodes using both rate and PR Logic pattern and rate analysis information.

### Details about double tachycardia detection

If PR Logic pattern and rate analysis identifies a double tachycardia, the device delivers the programmed therapies for the ventricular arrhythmia.

The device detects VF or FVT via VF in the presence of SVT if all of the following occur:

- The AF Evidence counter indicates atrial fibrillation, exclusive of far-field R-wave sensing.
- Ventricular detection occurs via the Interval or Combined Count criterion.
- The V-V median interval is greater than or equal to the SVT Limit. ≥
- The rhythm is A:V dissociated → vuol dire regolarità nell'intervallo di tempo tra onde atriali e ventricolari

The device detects VT or FVT via VT in the presence of SVT if these criteria are met and

- the ventricular cycle length is very regular (regularity of at least 75%).

↓
Se è molto regolare c'è doppia tachicardia



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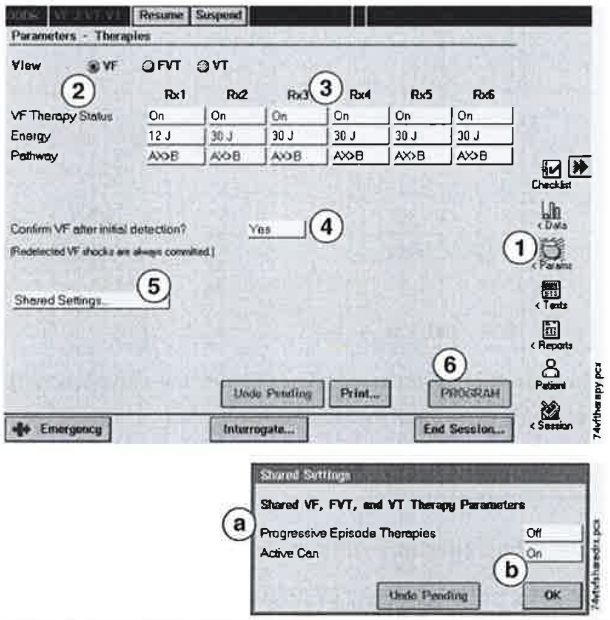
## Restrictions

Review the following information before programming VF Therapy parameters.

6 terapie, possono essere on o off → solo per le ultime e deve essere in ordine crescente

**Energy** – The energy settings for VF therapies 3 - 6 must be programmed to 10 J or greater. In addition, VF therapies must be programmed to be at least equal to the energy of the previous therapy or increasingly aggressive. That is, one VF therapy cannot be followed by another with a lower energy setting.

## How to program VF therapies







To program VF therapies:

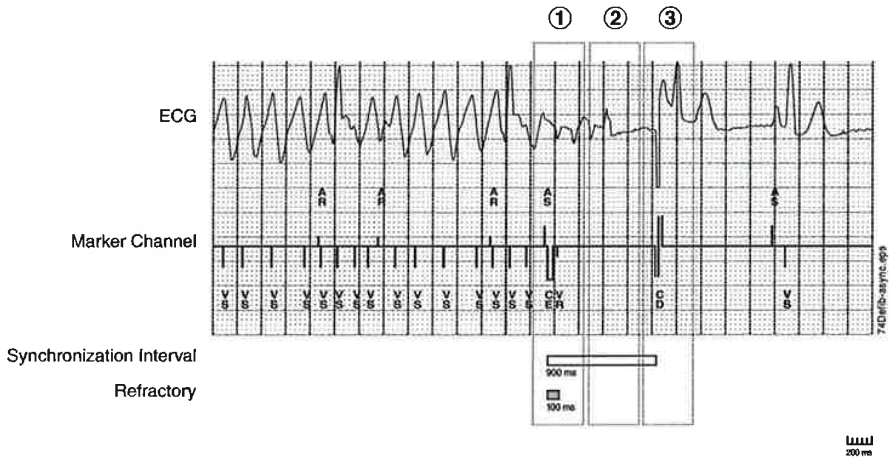
1. Select Params > Therapies.
2. Select [VF].
3. For each therapy (Rx1 - Rx6), select the desired values for VF Therapy Status, Energy, and Pathway.
4. Select a value for "Confirm VF after initial detection?"
5. To change the Active Can parameter value, select Shared Settings... .
   a. Select a value for Active Can.
   b. Select [OK].
6. Select [PROGRAM].

## Details about VF therapy

The device provides up to six defibrillation therapies to treat VF episodes. If a VF episode is detected, the device begins charging its high voltage capacitors. Once the capacitors are charged to the programmed energy, the device attempts to deliver the defibrillation pulse simultaneously with a sensed ventricular event. If the therapy cannot be synchronized to a sensed ventricular event, the device delivers the therapy asynchronously.

Any sensed ventricular event qualifies for therapy delivery unless it is a refractory event or an AVP event. If a refractory event occurs, the device ignores it and continues to attempt to synchronize. If an AVP event occurs, the device resets the delivery timer to 500 ms and continues to attempt to synchronize.

**Figure 7-2.** Defibrillation delivered asynchronously




1 After detecting VF, the device completes charging and starts a 100 ms refractory period and a 900 ms synchronization interval. The device does not deliver the charge synchronized to the refractory event.

2 Several low-amplitude VF events go unsensed.

3 After 900 ms pass, the device delivers the defibrillation therapy asynchronously.

### Confirming VF after initial detection

If the device is set to confirm VF after initial detection, and the device begins charging its capacitors for the first VF therapy, the device monitors the cardiac rhythm during and after charging to confirm that the VF remains present before delivering the therapy.

The device confirms the continued presence of VF using a sequence of confirmation intervals, each lasting 60 ms plus the programmed VT Interval.[1] It classifies any ventricular event that occurs within the confirmation interval as "arrhythmic" and any events after the interval as "normal."

[1] Or VF Interval, if VT Detection is set to Off or Monitor.

# Detecting prolonged tachyarrhythmias with High Rate Timeout

posso aver un ritmo veloce che non viene trattato. Alcuni soggetti lo tollerano per minuti, altri no

To ensure that fast ventricular rates are treated, the device provides High Rate Timeout. If a fast rhythm occurs, and the device withholds detection due to the PR Logic or Stability criteria, High Rate Timeout waits a programmable length of time and then suspends these criteria until the episode terminates. High Rate Timeout also includes the option to skip directly to VF therapies during sustained high rate episodes.

See details about High Rate Timeout on page 112.

## Parameters

| | * Medtronic nominal setting |
|---|---|
| **High Rate Timeout** (min) – Disables supplementary SVT detection criteria when high rate episode continues longer than the programmed time limit. | Off*, 0.75, 1, 1.25, 1.5, 2, 2.5, . . ., 5, 6, 7, . . ., 20, 22, 24, . . ., 30 |
| **High Rate Timeout Therapy** – Option to treat sustained high rate episodes with the therapies for the detected episode type or to treat all high rate timeout episodes with VF defibrillation therapy (with no VF confirmation). | Zone Appropriate*, Skip to VF Therapy ↓ più efficace |

## Considerations

Review the following information before programming High Rate Timeout parameters.

**High Rate Timeout and inappropriate therapies** – Because High Rate Timeout can disable the PR Logic and Stability detection criteria, it may cause the device to deliver tachyarrhythmia therapies inappropriately (for example, during sinus tachycardia or atrial fibrillation).

ATP antitachycardia pacing



# Treating VT and FVT with antitachycardia pacing

The device can respond to a VT or FVT episode by delivering antitachycardia pacing (ATP) or cardioversion therapy to the patient's heart. ATP therapies are designed to interrupt the reentrant activation pattern of a VT or FVT with pacing stimuli, restoring the patient's normal sinus rhythm. Because ATP therapies use pacing-level stimulation instead of high voltage shocks, they are much less painful for the patient than cardioversion therapy.

You can program the device to deliver a sequence of up to six VT therapies and six FVT therapies and can program a portion of these as ATP therapies. You can select Burst, Ramp, or Ramp+ ATP therapy and can set the parameters for each enabled therapy separately.

See details about ATP therapies on page 134.

## Parameters for all ATP therapies

* Medtronic nominal setting

| | |
|---|---|
| **VT (or FVT) Therapy Status** – Enables or disables a VT Therapy or FVT Therapy. | On*, Off |
| **Therapy Type** – Cardioversion or ATP therapy to treat VT or FVT episodes (choose Burst, Ramp, or Ramp+ to enable ATP therapy). | CV, Burst, Ramp, Ramp+ |
| **Anti-Tachy Pacing Minimum Interval** (ms) – Minimum pacing interval for all ATP therapies. | 150, 160, . . ., 200*, . . ., 400 |
| **V. Amplitude** (V) – Voltage of the ventricular pacing pulses delivered during all ATP pacing pulses. | 0.5, 1, . . ., 4, 5, 6, 8* |
| **V. Pulse Width** (ms) – Duration of the ventricular pacing pulses delivered during all ATP therapies. | 0.03, 0.06, 0.1, 0.2, . . ., 1.6* |
| **V. Pace Blanking** (ms) – Ventricular blanking period following the pacing pulses delivered during all ATP therapies. | 150, 160, . . ., 240*, . . ., 440 |

## Parameters for Ramp+ therapy

passo programmare inizialmente un n° di sequenze e poi la generazione degli intervalli della sequenza è diretta

all'interno la distanza tra 1° e 2° impulso, tra 2° e 3°, 3°-4°... in corrispondenza di ogni sequenza aggiunge un impulso

| | * Medtronic nominal setting |
|---|---|
| **Initial # Pulses** – Number of pulses in first Ramp+ sequence. | 1, 2, 3*, . . ., 15 |
| **R-S1 Interval** (%) – Pacing interval of the first Ramp+ pulse as a percentage of the tachycardia cycle length. | 50, 53, 56, 59, 63, 66, . . ., 75*, . . ., 84, 88, 91, 94, 97 |
| **S1-S2 Interval** (%) – Pacing interval of the second Ramp+ pulse as a percentage of the tachycardia cycle length. | 50, 53, 56, 59, 63, 66, 69*, . . ., 84, 88, 91, 94, 97 |
| **S2-SN Interval** (%) – Pacing interval of the remaining Ramp+ pulses as a percentage of the tachycardia cycle length. | 50, 53, 56, 59, 63, 66*, . . ., 84, 88, 91, 94, 97 |
| **# Sequences** – Number of sequences in the Ramp+ therapy. | 1, 2, . . ., 5*, . . ., 10 |

## Considerations

Review the following information before programming ATP therapy parameters.

**VT and FVT therapies –** You should not use ATP therapies exclusively to treat VT or FVT episodes. At least one VT therapy and one FVT therapy should be programmed to a maximum energy cardioversion.

**Progressive Episode Therapies –** If Progressive Episode Therapies is turned on, the device may skip programmed ATP therapies and deliver cardioversion to ensure that each therapy delivered during an ongoing episode is at least as aggressive as the previous (see page 148).

### Ramp+ pacing therapy

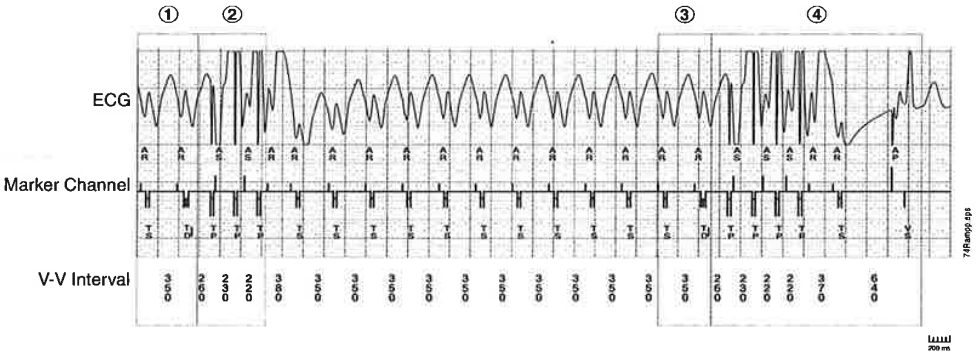
The first pulse of each Ramp+ sequence occurs at a programmed percentage of the tachycardia cycle length, timed from the sensed event that fulfills tachycardia detection. The second pulse interval is calculated using the S1-S2 percentage. Any remaining pulses in the sequence are delivered at the S2-SN percentage.[1]

If the tachycardia is redetected, the device applies the programmed percentages to the new cycle length to calculate the pacing intervals for the next Ramp+ sequence. Each sequence adds one pacing pulse per sequence.

Cerco di variare la temporizzazione

In Figure 7-7, two Ramp+ therapy sequences are delivered. The second therapy sequence terminates the VT.

**Figure 7-7.** Device delivers two sequences of Ramp+ pacing therapy




1 The device detects VT.

2 The first Ramp+ sequence consists of three pacing pulses with intervals of 260, 230, and 220 ms. The VT is not terminated.

3 The device redetects VT.

4 The second Ramp+ therapy repeats the first three intervals and adds another pulse with a 220 ms interval, which terminates the VT.

[1] Ramp + pacing therapy is delivered in VOO mode.

Nel caso della cardioversione è DA cartella che vi sia stato o meno l'episodio, nel caso di defibrillatore è solo un'epizia

la terapia avversiva sincronizzata al ritmo cardiaco
VT, FVT → scarica solo se sincronia, se non c'è la fa annulla la terapia, è proprio dove una scarica che non serve non sincronizzata alla FC che aspettare e far continuare la VT o la FVT



## Details about cardioversion therapy

When a VT or FVT episode is detected and the next programmed therapy is a cardioversion, the device begins charging its high voltage capacitors and attempts to confirm the continued presence of the tachyarrhythmia. If the arrhythmia terminates, the device cancels the therapy.

If the arrhythmia is still present when the capacitors are charged to the programmed energy, the device delivers the cardioversion pulse synchronized to a sensed ventricular event. If synchronization is not possible, the device cancels the therapy.

### Capacitor charging period

To deliver a cardioversion therapy, the device must first charge its high voltage capacitors to the programmed energy. The length of time required to charge the capacitors depends on the programmed energy, battery depletion, and the length of time since the last capacitor formation. See Table 1-6 on page 23 for typical full energy capacitor charging periods.

### Delivery pathway electrodes

The device can deliver cardioversion therapies via the following high voltage electrodes:

- Can (HVA) – device can
- RV (HVB) – RV coil
- SVC (HVX) – optional electrode (for example, an SVC coil)

If an optional electrode is used, you can disable the Active Can feature. If you do so, the device delivers cardioversion therapies between the RV (HVB) and SVC (HVX) electrodes only.

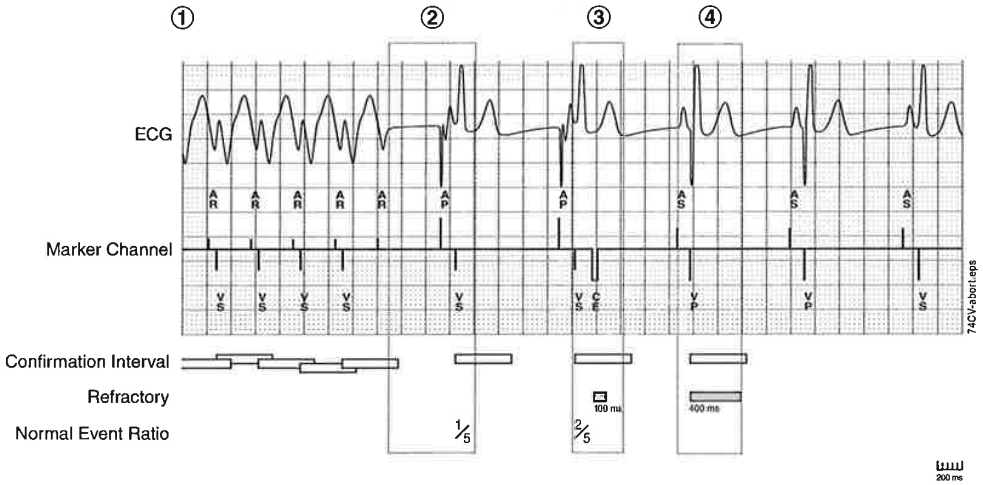
### Energy

The device can deliver up to 30 joules,[1] which corresponds to a stored energy of 35 joules.[2] For a comparison of delivered and stored energy levels, see Table 1-7 on page 24. The energy level is programmed independently for each cardioversion therapy.

[1] Delivered energy of biphasic waveform into 75 ohms.
[2] Derived from the peak capacitor voltage, which is always greater than the energy delivered by the device.

On each ventricular event during charging, the device reviews the last five events since charging started. If four of the last five ventricular events were normal, the device stops charging and cancels the therapy (see Figure 7-9).

**Figure 7-9.** Cardioversion therapy cancelled when VT terminates spontaneously




1 The device has detected VT, is charging its capacitors for cardioversion, and is confirming the arrhythmia using a confirmation interval of 460 ms (VT Interval + 60 ms).

2 The VT spontaneously terminates, and normal sinus rhythm resumes.

3 The charging period ends, and synchronization starts. At this point, the device stops the confirmation process and disregards the normal event ratio. Any normal event after charging will abort the cardioversion therapy.

4 The cardioversion therapy aborts when a normal event occurs during synchronization.

### Synchronizing cardioversion after charging

Once charging ends, the device attempts to synchronize the cardioversion therapy to a qualified ventricular event but also continues to confirm the presence of the arrhythmia. An event qualifies for delivery if it is non-refractory and meets one of the following conditions:

- the second arrhythmic ventricular event and is outside an AVP interval
- the third arrhythmic ventricular event

Condensatori prodi e leggeri
tempo di carica: 10-15 minuti fino a quando la capacità del condensatore sia prossima al valore nominale
↓
ricarica ogni 1-6 mesi

Insegue errore un equilibrio tra tempo di carica

formado frequentemente i condensatori sono meno di avere la capacità nominale previsto e il tempo di ricarica è quello previsto



## Optimizing charge time

Si li forma meno frequentemente il tempo di ricarica del condensatore aumenta

ogni ricarica completa significativamente di circa un mese di vita

The high voltage capacitors must be formed (or *conditioned*) periodically to maintain quick charging for high voltage therapy. You can use the Automatic Capacitor Formation feature to ensure they are formed regularly.

The device can be programmed to automatically adjust the capacitor formation interval for interactive management of charge time and device longevity.

See details about managing charge time on page 215.

### Parameters

* Medtronic nominal setting

| | |
|---|---|
| Minimum Auto Cap Formation Interval | Auto*, 1 – 6 months |

### Considerations

**Formation interval and longevity** – A shorter formation interval provides faster charge times by optimizing the efficiency of the capacitors. However, each capacitor formation includes a full energy charge, reducing the longevity of the device.

Assess the patient's requirements for faster therapy delivery relative to the effect on device longevity. Each full energy charge decreases the longevity by approximately 24 days.

When you program a new automatic formation interval, always confirm that the charge time is adequate at present. Either perform a manual capacitor formation or evaluate a recent full energy charge time recorded in the Battery and Lead Measurements display.

You can use the Patient Alert monitoring feature to receive prompt notice if a long charge time has occurred.

## Quick Look observations

Observations provided by Quick Look are based on an analysis of interrogated data and programmed parameters. Three types of observations are provided: parameter, device status, and episode data.

**Parameter observations –** Example observations include:

- cautionary messages about the programmed detection and therapy configuration
- pending parameter values
- an ATP therapy that has been disabled by the Smart Mode feature

**Device status observations –** Example observations include:

- Active Device Status Indicators
- replacement indicator warnings (ERI and EOL)
- a pacing lead impedance of greater than 3000 ohms or less than 200 ohms
- a high voltage lead impedance of greater than 200 ohms or less than 20 ohms
- Patient Alert messages

**Episode data observations –** Example observations include:

- For each programmed detection zone, the following types of episodes are listed:
  - episodes with unsuccessful therapies, in which more than one therapy was attempted
  - episodes longer than 30 seconds
  - episodes that accelerated to VF
  - monitored episodes
  - episodes where High Rate Timeout occurred
- If more than one episode has occurred for a particular type, the Episode Data Observations section highlights the most recent episode and the total number of episodes of that type.

(continued)* Medtronic nominal setting

**Lead Impedance Out of Range** – indicates that the daily impedance measurement is out of range; could be triggered by a dislodged or improperly connected lead.

| | |
|---|---|
| **Alert Urgency** | Low*, High |
| **A. Pacing, V. Pacing Impedance** (ohms) | |
| Enable | On, Off |
| Minimum Threshold (Less than) | 200*, 300, 400, 500, |
| Maximum Threshold (Greater than) | 1000, 1500, 2000, 3000* |
| **Defibrillation and SVC (HVX) defibrillation** (ohms) | |
| Enable | On, Off |
| Minimum Threshold (Less than) | 20*, 30, 40, 50 |
| Maximum Threshold (Greater than) | 100, 130, 160, 200* |

**Low Battery Voltage ERI** – indicates that the daily automatic battery voltage measurement has been at or below the 2.62 V (the Elective Replacement Indicator voltage level) on three consecutive days.

| | |
|---|---|
| Alert Enable - Urgency | Off, On-Low*, On-High |
| Battery Voltage Threshold (V) | 2.62 (ERI) (fixed) |

**Excessive Charge Time ERI** – indicates that the charging period equals or exceeds the Charge Time Threshold.

| | |
|---|---|
| Alert Enable - Urgency | Off, On-Low*, On-High |
| Charge Time Threshold (seconds) | 16 (fixed) |

**Number Of Shocks Delivered in an Episode** – indicates that the number of shocks delivered in an episode is greater than or equal to the programmed Number of Shocks Threshold.[a]

| | |
|---|---|
| Alert Enable - Urgency | Off, On-Low*, On-High |
| Number of Shocks Threshold | 1, 2, 3*, 4, 5, 6 |

**All Therapies in a Zone Exhausted for an Episode** – indicates that a specific arrhythmic episode was re-detected after all programmed therapies for that type of episode were delivered.

| | |
|---|---|
| Alert Enable - Urgency | Off, On-Low*, On-High |

**VF Detection/Therapy Off** – indicates that VF detection or more than two VF therapies have been turned off for at least six hours. This alert is programed on in the shipped device and sounds with a High urgency alert tone.[b]

| | |
|---|---|
| Alert Enable - Urgency | Off, On-High* |

Il cardiologo vede il paziente molto spesso per controllare se il dispositivo è programmato correttamente. Visite ogni 3-6 mesi
Va sempre (anche mai) è il cardiologo a effettuare la visita! anche il boring. lo fa!
quando il cardiologo sceglie il dispositivo non va a guardare solo la cartella "tenuta" del generatore ma anche l'interfaccia del software per i dati contenuti del portatore



## Streamlining follow-ups with Checklist

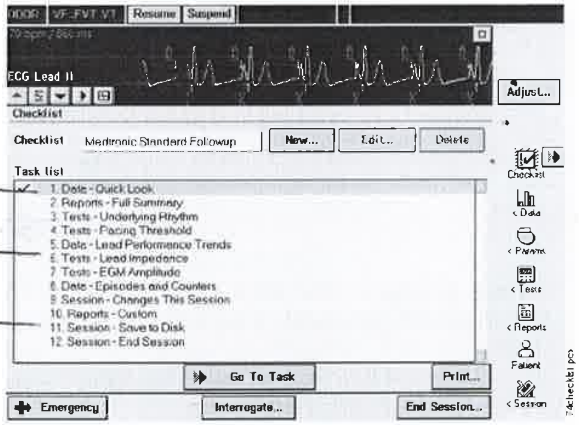
The Checklist feature provides a method of cataloging tasks performed during routine procedures. Selecting a task from the Checklist displays the programmer screen associated with that task. To display the programmer screen for the next task in the selected checklist, select the double-arrow icon next to the Checklist icon.

**Figure 11-1.** Checklist screen

riassunto delle attività principali compiute

riassunto delle condizioni annuale cronico

Salvo su disco: importante anche legale che clinico




che la possibilità di aumentare il numero di task

visione degli episodi, patient alert, efficacia della terapia, cartella degli episodi e dell'efficacia della terapia episodi VT, VF...

The Checklist screen displays a check mark next to the names of any programmer screens visited during a session. This provides a general indication of the tasks performed during a session.

Two checklists are provided: the Medtronic Standard Implant checklist and the Medtronic Standard Follow-up checklist. In addition to these standard checklists, you can create customized checklists.

33 pagg

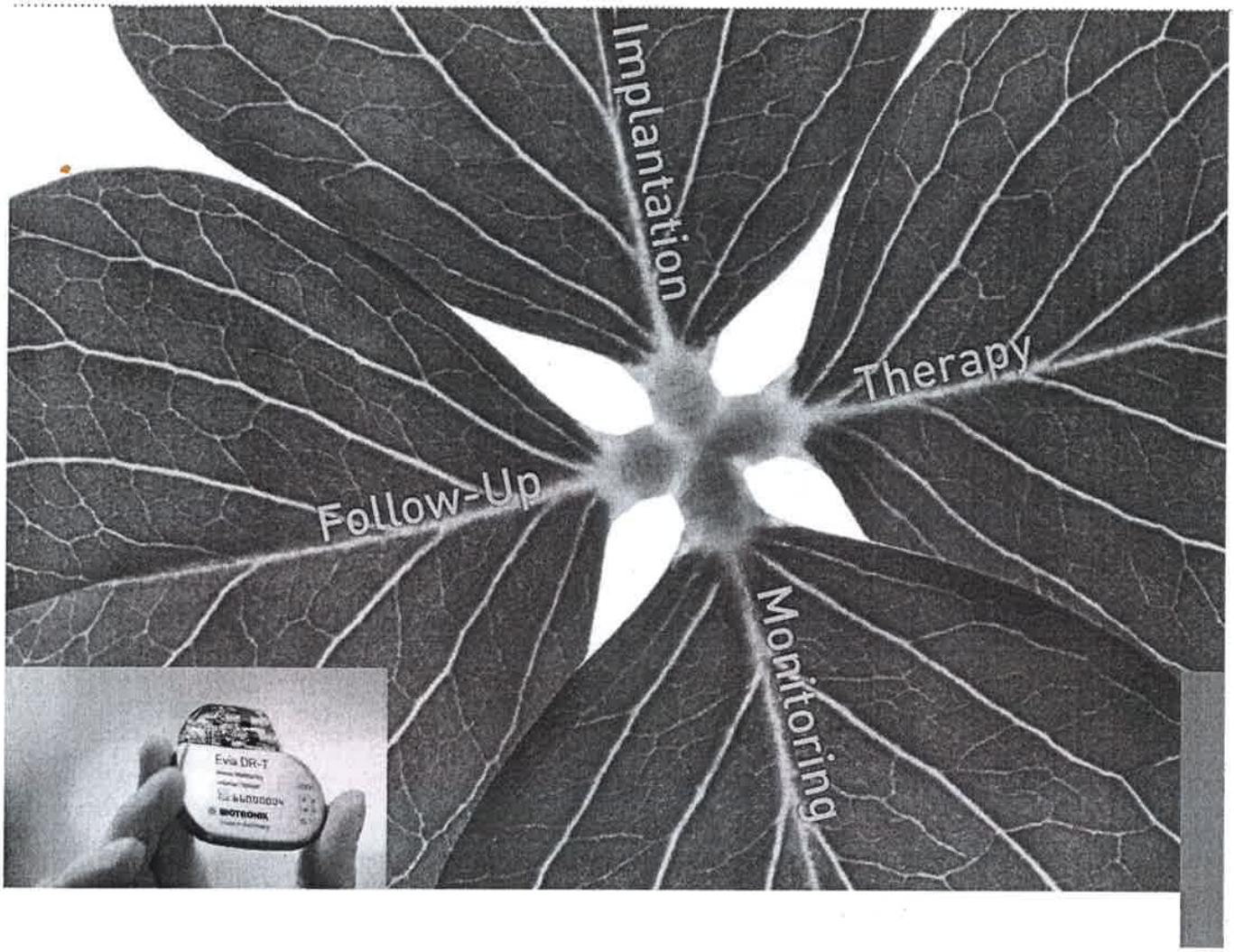
Cardiac Rhythm Management

Function Manual

Evia

# Evia
# Function Manual

ProMRI®




BIOTRONIK
excellence for life

Comunicatore: comunica con il pacemaker e invia i dati tramite via telefonica al centro servizi

## System Overview

**Parts**

The device system consists of the following parts:

- Device with connections for unipolar or bipolar sensing and pacing
- Suitable leads, adapters and approved accessories
- Programmer
- Current device programs → eventuali adattatori e accessori

**Device**

The device's housing is made of biocompatible titanium, welded from outside and thus hermetically sealed. The ellipsoid shape facilitates ingrowth into the pectoral muscle area.

The housing serves as an antipole in the case of unipolar lead configuration. BIOTRONIK provides silicone-coated devices to avoid muscle twitching near the implanted pacemaker in the case of unipolar pacing.

The labeling provides information about the device type and arrangement of the connections.

Il catetere serve da elettrodo nel caso impiegare possibile stimolazioni del grande pettorale passo attorno il contatto metallo-tessuto rivestendo il pace-maker con un materiale isolante lasciando una fase preferenziale diretta verso la cute che non può essere stimolata può essere messo sotto il gran pettorale

**Leads**

CATETERE

The leads are coated with biocompatible silicone. They can be flexibly maneuvered, are stable long-term, and are equipped for active or passive fixation. They are implanted using a lead introducer set. Some leads are coated with polyurethane to increase the sliding properties of the lead.

The coating of steroid-eluting leads reduces inflammatory processes. The fractal design of the leads provides for low pacing thresholds, high pacing impedance, and a low risk of oversensing.

↓ kΩ

**Programmer**

The portable programmer is used to transfer the current device program to the device. In addition to this, the programmer is used for interrogation and storage of data from the device. The programmer acts as an ECG and IEGM monitor with Miniclinic.

elettrogramma endocavitario

The programmer communicates with the device via the programming head. It has a TFT touch screen with a color display, on which the ECG, IEGM, marker and functions are shown simultaneously.

The programmer has, among others, the following functions:

- Perform all tests during in-office follow-up
- Display and print real-time and saved IEGMs with annotated markers
- Determine the pacing threshold

**BIOTRONIK Home Monitoring®**

gestisce direttamente la terapia trasferendo al comunicatore

In addition to effective pacing therapy, BIOTRONIK provides a complete therapy management system:

- With Home Monitoring, diagnostic and therapeutic information and technical data are automatically sent to a stationary or mobile transmitter via an antenna in the device header. The data are encrypted and sent from the transmitter to the BIOTRONIK Service Center via the cellular phone network.
- The received data are deciphered and evaluated. Each physician can set the criteria for evaluation to be used for each patient and can configure the time of notification via E-mail, SMS or fax.
- A clear overview of the analysis results is displayed for the attending physicians on the protected Internet platform HMSC (Home Monitoring Service Center).
- Data transmission from the device is performed on a daily basis with the device message. Depending on the transmitter used, these data are passed on immediately or, if the data is normal, it is collected for up to 2 weeks.
- Device messages, which indicate special events in the patient's heart or in the device, are forwarded immediately.

(2)

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## Diagnostic and Therapy Functions

**General overview**

All the systems have extensive features that allow quick diagnosis and delivery of safe therapy for bradycardia conditions.

- Automatic functions make it easy and fast to implant, configure, and check the pacemaker.
- Auto-initialization after implantation: the device automatically detects the implanted leads, sets the polarity and activates the automatic functions after 10 min.

**Diagnostic functions**

- Data from the last 10 interrogations and follow-ups are recorded as well as arrhythmia episodes; they are stored together with other data to assess patients and the state of the device at any time.
- Automatic below-threshold impedance measurement is performed in the device independent of the pacing pulse in order to check the lead for proper functioning.
- When performing follow-ups using the programmer, the IEGM is indicated with markers after applying the programming head during the test procedure.

**Antibradycardia pacing**

- Sensing: the amplitudes of the P and R waves are measured in the device fully automatically to record varying amplitudes. The sensitivity for the atrium and ventricle is adapted automatically on an ongoing basis. The measurement data are averaged and the trend can be displayed.
- Thresholds: atrial as well as ventricular pacing thresholds are automatically determined in the device. Capture control is used to set the pacing amplitudes so that pacing is performed with the optimum atrial and ventricular amplitude for the patients with each change of the pacing threshold.
- Timing: pacing is particularly checked in the atrium by automatic adaptation of the atrial refractory period to avoid pacemaker-induced tachycardia. (Auto PVARP function: automatic post-ventricular atrial refractory period)
- Additional, special form of rate adaptation: an increased cardiac output requirement is detected using physiological impedance measurement. The measuring principle is based on contractile changes (ionotropy) of the myocardium (CLS function: Closed Loop Stimulation). The suitable rate adaptation is automatically initialized and optimized in CLS mode.
- Ventricular pacing suppression: unnecessary ventricular pacing is avoided by promoting intrinsic conduction ($V_p$ suppression function). The device can adapt itself to conduction changes. In the case of intrinsic conduction, the device switches to a DDD(R)-ADI(R) mode.

4

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## Replacement Indications

**Pacemaker operational status indications**

The time span from the beginning of service (BOS) to elective replacement indication (ERI) is determined by, among others, the following:

- Battery capacity
- Lead impedance
- Pacing program
- Pacing to inhibition ratio
- Pacemaker circuit properties

The following are the defined pacemaker operational statuses:

| | | |
|---|---|---|
| **BOS** | Beginning of Service | Battery is in good condition; normal follow-up. |
| **ERI** | Elective Replacement Indication | The replacement time has been reached. The pacemaker must be replaced. |
| **EOS** | End of Service | End of service time with regular pacemaker activity. |

**ERI activation**

ERI detection is automatically activated after the following events:

- Successful auto-initialization
- Storage for longer than 24 months

**ERI display**

ERI is displayed as follows:

- On the programmer after interrogation of the pacemaker
- By a defined decrease in the basic rate as well as the magnet rate

**Change of the pacing mode with ERI**

From dual-chamber modes, the pacemaker switches to single-chamber pacing. This replacement mode depends on the programmed mode and is displayed on the programmer.

**Deactivated functions with ERI**

The following functions are deactivated:

- Atrial pacing
- Night program
- Rate adaptation
- Atrial and ventricular capture control
- Rate fading
- Atrial overdrive pacing
- IEGM recordings
- Statistics
- Home Monitoring
- Rate hysteresis
- Ventricular pacing suppression

## Auto-initialization of the device

programmazione sempre più veloce e sicura

**Purpose**

Auto-initialization allows for device startup without manual programming or activation.

This can be used to significantly simplify the entire implantation procedure.

**Functional principle**

si attiva solo se sono stati impiantati misurando l'impedenza

Auto-initialization starts once a lead is connected to the device for the first time.

A 10-minute confirmation phase then begins, in which the polarity of the connected lead is checked.

If stable impedance relations and lead polarities have been verified in this phase, the device begins with normal device operation.

**Lead detection**

The device already regularly delivers measuring pulses to the lead connections during storage in the packaging.

If a lead impedance of less than 2500 Ohms is measured, the device begins the auto-initialization process.

**Confirmation phase**

A confirmation phase begins following initial lead detection.

This normally lasts 10 minutes. If 2 unipolar leads are connected, it can last up to 20 minutes.

During this confirmation phase, pacing and sensing function with the specified standard values. The automatic functions are disabled.

The device checks whether conditions are stable for lead polarity and lead impedance.

**Automatic termination of auto-initialization**

After successfully ending the confirmation phase, the device begins the standard program with automatic functions to adapt various parameters if no other permanent program has been transferred.

If the programming head is applied while auto-initialization is running, a corresponding status message is displayed in the status line of the user interface.

After successful completion of auto-initialization the follow-up page is available with all interrogated device data and possibilities for tests and parameter configuration.

**Programming the device prior to auto-initialization**

If the device was already programmed during storage, auto-initialization is also triggered by connecting a lead.

Then the programmed permanent program is active in the confirmation phase with the pre-programmed lead polarity and the automatic function is disabled.

After a successful confirmation phase, the automatic functions are also available.

**Manual termination of auto-initialization**

Auto-initialization is canceled if a permanent program is transmitted during the confirmation phase. Then the device works immediately with the permanent program.

**Note:** Once auto-initialization is canceled manually, it cannot be restarted or repeated!

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## Standard Pacing Modes

**Overview**

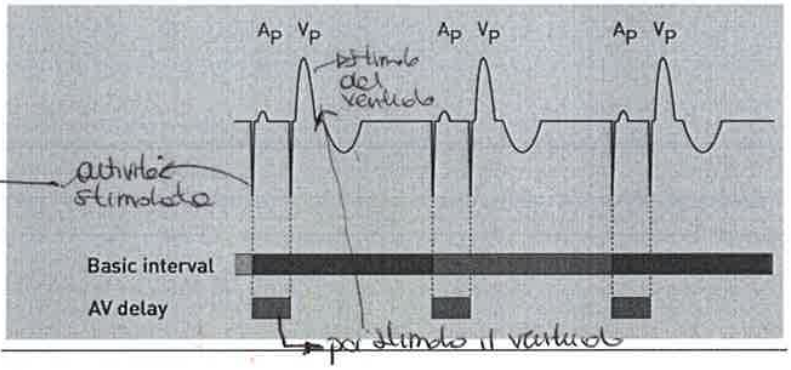
The following pacing modes will be described:

- DDD, DDI, DVI, VDD
- AAI, VVI
- AOO, VOO, DOO
- Triggered modes
- OFF (only possible temporarily during follow-up for diagnostic purposes)

**DDD mode**

In the DDD mode, the basic interval starts with an atrial sensed (As) or atrial paced event (Ap) or a ventricular sensed event without a preceding atrial event (PVC = premature ventricular contraction). If no atrial sensed event occurs within the basic interval, atrial pacing takes place at the end of the basic interval and the basic interval is restarted.

**AV sequential pacing in the DDD mode in the case of missing intrinsic cardiac events**




**Atrial/ventricular events**

Atrial/ventricular sensed events have the following impact in DDD mode:

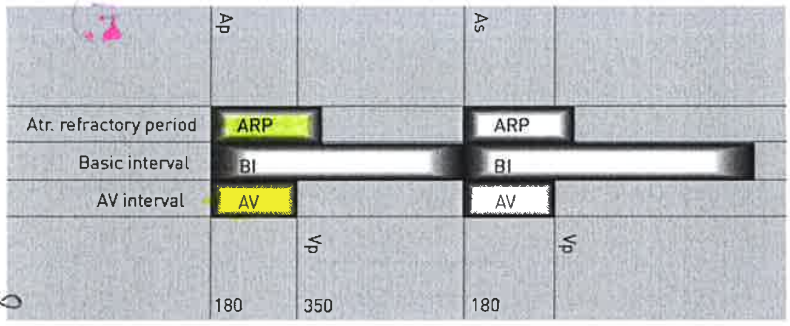
| If... | Then ... |
|---|---|
| an atrial sensed or paced event takes place, | the AV delay starts with the basic interval. |
| no ventricular sensing occurs during the AV delay, | the pacemaker delivers a pacing pulse in the ventricle at the end of the AV delay. |
| ventricular sensing (Vs) occurs during the AV delay, | the delivery of a ventricular pulse (Vp) is inhibited. |
| atrial sensing occurs, | atrial pacing is inhibited and the basic interval is restarted. |

1 2

**Definition: Atrial refractory period in the device's timing**

- The atrial refractory period (ARP) starts with an intrinsic sense or pace.

**Each of the following atrial events (As, As(AV), Ap, Ap(AUR) and As(PVARP)) starts an atrial refractory period (ARP).**



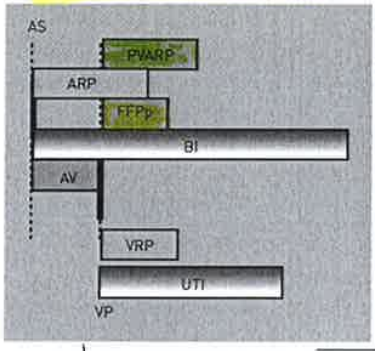

**Mode-controlled atrial refractory period setting**

| Setting | Mode |
|---|---|
| AUTO | DDD(R), DDD-CLS, DDI(R), VDI(R), VDT(R), DDD(R)-ADI(R) |
| 300 ... [25] ... 775 ms | AAI(R), AAT(R), DDT |

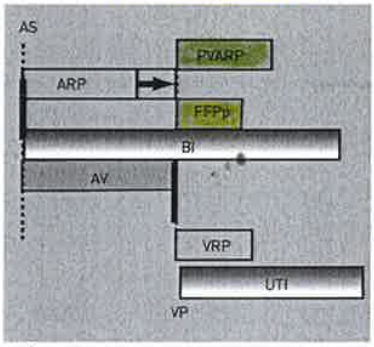
**Timing with the atrial refractory period setting AUTO**

- The atrial refractory period (ARP) is automatically configured in addition to the AV delay.
- The atrial refractory period (ARP) is 225 ms minimum. It is also used after AsPVARP.

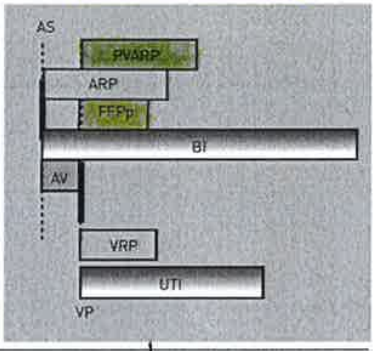
225 ms-FFP < AV delay < 225 ms




AV delay > 225 ms



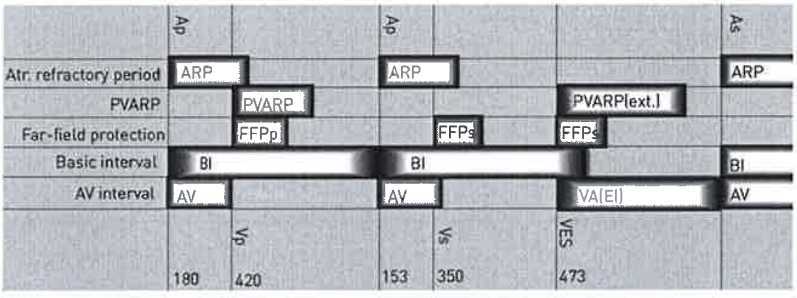

225 ms-FFP > AV delay



**Post-ventricular atrial refractory period (PVARP)**

The post-ventricular atrial refractory period function prevents atrial pacing from being triggered directly after a ventricular event. This prevents a pacemaker-mediated tachycardia (PMT).

- In all P-synchronous modes (e.g., DDD), a PVARP starts in the case of the following events: Vp, Vp (WKB), Vp (SW), Vp (BU)
- In all R-synchronous modes (e.g., DDI), a PVARP starts in the case of the following events: Vp, Vp (SW), Vp (BU), PVC, Vs and Vs (AVC).




**AUTO PVARP**

After ending a pacemaker-mediated tachycardia (PMT), PVARP and PVARP after PVC are automatically extended by 50 ms.

The limit for PVARP is:

- Value of the VA criterion + 50 ms.
- Minimum automatic setting: 175 ms

If no pacemaker-mediated tachycardia (PMT) is detected within 7 days, the Auto PVARP function automatically reduces PVARP and PVARP after PVC by 50 ms.

13

fine per modalità attivo de ventricolo - guidate quando la modalità è inibita

## AV Safety Delay

se modifichiamo il potenziale in un punto del corpo lo modifichiamo in tutto il corpo

**Protection against pulse inhibition**

If an atrial pace triggers ventricular oversensing through crosstalk, undesired pulse inhibition in the ventricle can result. Sensing of the atrial pulse delivery in the ventricular channel during the AV delay can be incorrectly interpreted as intrinsic ventricle excitation.

l'impulso di stimolazione agli atri può essere sentito dai ventricoli → oversensing → inibizione della stimolazione ventricolare

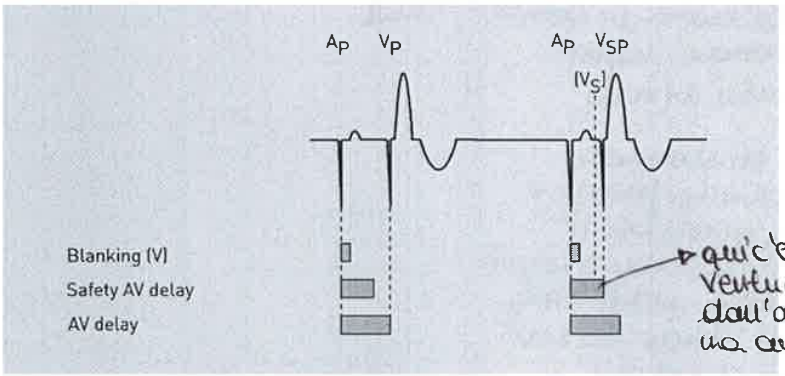
**Description**

In the DDD(R), DDI(R), and DVI(R) pacing modes, the AV safety delay is started with atrial pacing. If a ventricular sensing occurs within the AV safety delay, the pacemaker paces in the ventricle at the end of the interval (Vsp = ventricular safety pace). If the AV delay is shorter than the AV safety delay, pacing occurs at the end of the AV delay.

This prevents ventricular pulse inhibition through ventricular sensing of atrial pacing (crosstalk).

If AV sequential pacing is observed with an AV delay corresponding to the AV safety delay, this may be evidence of ventricular crosstalk (recognition of atrial pulse delivery).

In order to avoid crosstalk, the following can be defined: a lower atrial pulse energy, a lower ventricular sensitivity (higher numerical value) and/or a longer ventricular blanking period.




qui c'è attività ventricolare derivante dall'attività atriale ma andrebbe oltre *

un AV = 160 ms ma se l'as FC è elevata si scende a 75 ms

The AV safety delay is not programmable and lasts 100 ms.

in corrispondenza della stimolazione dell'atrio faccio partire un intervallo AV che non è quello normale ma è quello impostato di scelta, alla cui fine il p.m. stimola il ventricolo. Se l'intervallo AV dovesse essere più breve di quello di scelta allora la stimolazione del ventricolo avviene alla fine dell'intervallo AV

* inibirà la normale attività ventricolare. Quindi AV di sicurezza permette di non far leggere l'attività ventricolare Vs come un'effettiva attività che non permetterebbe la vera e propria attivazione del ventricolo e si perderebbe così una stimolazione

atrio guidata

## VDD mode

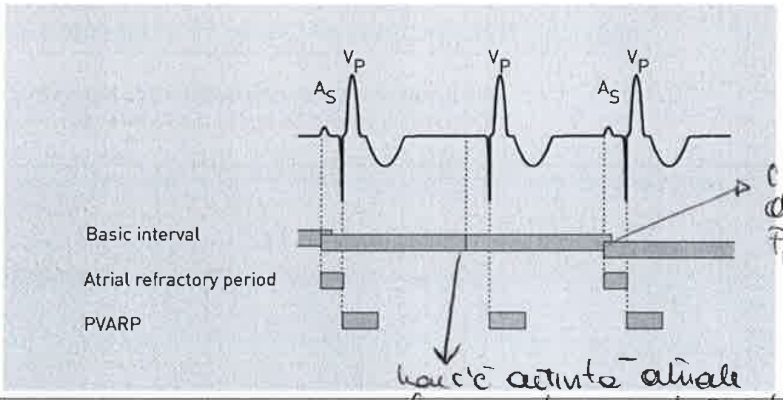
The VDD mode is derived from the DDD mode. The difference is that no atrial pacing takes place.

**Sensed events**

Sensed events have the following impact in VDD mode:

- If the sensed event does not take place, then the basic interval starts with an atrial sensed event, a premature ventricular contraction or with the end of the preceding basic interval.

**Prevention of pacemaker-mediated tachycardias in VDD mode**



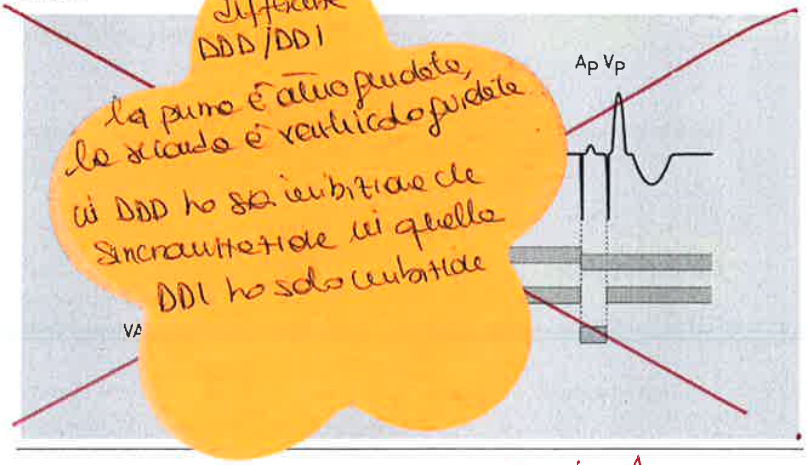

c'è attività atriale facce parte attività ventricolare

ventricolo guidata

## DDI mode

In contrast to the DDD mode, the basic interval in DDI mode does not start with a P wave, but rather with ventricular sensed or paced events. The VA interval is started together with the basic interval.

**AV sequential pacing in ... mode in the case of missing intrinsic cardiac events**




differenze DDD/DDI
la prima è atrio guidata, la seconda è ventricolo guidata
il DDD ha sia inibizione che sincronizzazione il quello DDI ha solo inibizione

$V_S$, $V_P$ intervallo base inizia con atti. ventr.
VA
dal punto di vista fisiologico non ha un significato

osservo attività atriale il VA se c'è
$V_S$, $V_P$ $A_P$
VA AV
allora
lo impulso di stimolo dell'atrio
osservo il ventricolo se non c'è attività $A_P$ $V_P$
VA AV
inizio IB

VA non termina prematuramente ma per far partire AV aspetta fine di VA quindi da AS al prossimo VA non c'è sincronizzazione

$V_S$ $V_P$ $A_S$
VA
differenza con DDA
non c'è sincronizzazione perché da $V_S$ al nuovo evento

se c'è
$V_S$ $A_P$ $V_S$
VA AV VA

16

**DOO mode**

Asynchronous AV sequential pulses are emitted in this pacing mode (DOO).

**Note:** When programming the DOO mode, you should consider the risks associated with asynchronous ventricular pacing.

**Triggered pacing**

The triggered pacing modes correspond to the respective demand pacing modes with the following distinction: no pulse inhibition takes place upon sensing of an atrial/ventricular event outside of the refractory period. Instead, pulse delivery is carried out immediately in the respective chamber.

The corresponding pacing modes are:

| Pacing mode | | | | | | |
|---|---|---|---|---|---|---|
| Demand (inibite) | DDD | VDD | DDI | DVI | AAI | VVI |
| Triggered | DDT | VDT | DDI/T | DVT | AAT | VVT |

There is no AV safety delay in the DDT, DDI/T, and DVT pacing modes. This is not necessary because ventricular pulse inhibition in cases of crosstalk (ventricular sensing of the atrial pacing pulse) cannot occur in these modes.

**Sensed events**

Sensed events have the following impact in the triggered pacing modes:

| If... | Then ... |
|---|---|
| atrial/ventricular events are sensed outside of the refractory period, | no pulse inhibition occurs, but a pulse is delivered immediately out in the respective chamber. |
| ventricular sensed events occur during the AV delay, | the basic interval is not restarted in pacing modes DDI/T and DVT. |

**VDI mode**

The VDI mode is derived from the VVI mode. In contrast to the latter, the VDI mode enables registration of intra-atrial events. However, the timing corresponds to that of the VVI mode.

**Retrograde conduction measurement**

The VDI mode is designed for measuring retrograde conduction with the IEGM and/or the marker function.

- If there is retrograde conduction,

  then it can be measured as the time interval between a ventricular paced or sensed event and the subsequent atrial sensed event. This can be measured using the programming device or an additional ECG device.

**OFF mode**

No pacing pulses are delivered in the OFF mode. External pulse control (NIPS) represents one exception to this.

**Purpose**

Without external pulse control, the OFF mode is used for detection and morphological evaluation of the intrinsic rhythm.

- With external pulse control, the OFF mode is used for electrophysiologic studies and to combat tachycardia.
- The pulse and control parameters remain adjustable in the OFF mode because the external pulse control function of the programmer can be used to trigger pacing pulses and to transmit sensed events to the programmer. Note that sensing is limited by the refractory period, whereas pacing is not.

18

## Rate Hysteresis

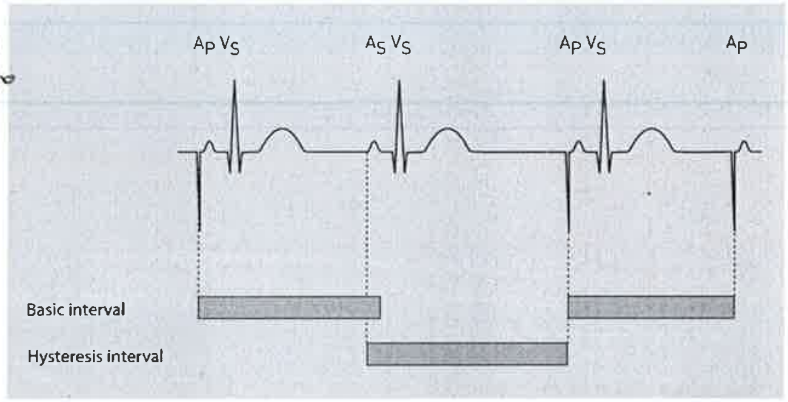
**Definition** The rate hysteresis is specified as the difference from the basic rate. In rate-adaptive pacing, the hysteresis remains constant while the hysteresis rate follows the variable (sensor-controlled) basic rate.

**Description** To preserve a spontaneous rhythm once it occurs, a rate hysteresis can be programmed in the modes DDD(R), DDT(R), DDI(R), VDD(R), VDI(R), VVI(R), VVT(R), AAI(R) and AAT(R).

In this case, after a sensed event, the pacemaker not only waits for the duration of the basic interval for a new sensed event, but also for the duration of the longer hysteresis interval before pacing.

This means that the pacemaker tolerates a spontaneous rhythm whose rate lies below the basic rate. However, the intrinsic rate must be higher than the rate that corresponds to the hysteresis interval.

If a sensed event does not occur within the hysteresis interval, a pacing pulse is delivered at the end of the hysteresis interval. The next interval then corresponds to that of the basic rate or the interval determined by the sensor.




- In the pacing modes DDD(R), DDT(R), VDD(R), AAT(R) and AAI(R), the hysteresis interval starts with an atrial sensed event.
  In the pacing modes DDI(R), VVI(R), VVT(R), and VDI(R), it starts with a ventricular sensed event.
- In the pacing modes DDD(R), DDT(R) and VDD(R), it also starts with a premature ventricular contraction.

**Note:** If the rate hysteresis is to be used in the DDI mode, the AV delay must be programmed shorter than the intrinsic conduction time. Otherwise, the pacemaker paces at the hysteresis rate instead of the basic rate even in the absence of spontaneous activity.

Stimolare il ventricolo quando non necessario può essere causa di scompenso cardiaco

Ritmo base dell'essere un buon compromesso tra ritmo intrinseco e stimolato

Se il paziente ha un ritmo basso il p.m. viene regolato con un ritmo alto ma in questo caso prende il sopravvento sul ritmo del paziente e il cuore viene stimolato solo per dal p.m.

ISTERESI: fenomeno per cui il valore assunto dalla grandezza dipendente da cui è determinato dalle che dai valori istantanei anche dai precedenti

abbiamo un $I_B$ con durata 800 ms in modalità DDD (quindi $I_B$ parte da evento atriale) prima che termini l'$I_B$ abbiamo un evento ventricolare spontaneo → quindi $I_B$ è più lungo del ciclo

↳ allora il p.m. applica all'$I_B$ programmato un intervallo di tempo che è l'I, di valore più tanto che c'è attività spontanea allungo l'intervallo base in modo da fare avere un intervallo più lento ma se non ho attività spontanea ritorno all'intervallo base

più tanto c'è attività spontanea allungo l'intervallo in modo da rallentare l'attività spontanea

Vedo un'att. att. spontanea quindi faccio passare un po' di tempo per controllare che ne arrivi un'altra, se non c'è faccio partire un'attività stimolata con $I_B$, se c'è ho l'onda successiva

20

lo stimolatore alla frequenza base ma non permette ad un ritmo di tenersi per basso di partire. Allora lei presenta di ritmo base stimolato (almeno 150 stimoli atriali) abbassa la fq. di stimolaz. a quella di isteresi

## Scan Rate Hysteresis

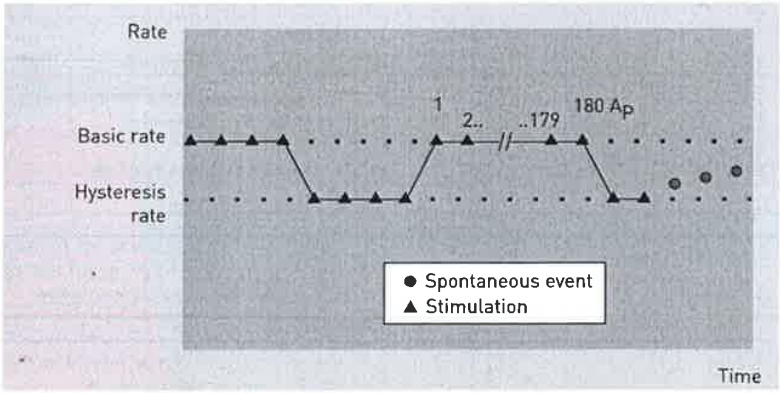
**Definition**

The scan rate hysteresis promotes a spontaneous rhythm during longer phases of pacing.

**Description**

If the scan hysteresis is activated, the pacemaker will reduce the pacing rate temporarily to the hysteresis rate after every 180 consecutive atrial paced events. The number of scan intervals can be programmed.

If no intrinsic event is sensed during the scan intervals, pacing at the basic rate is resumed (at the sensor rate in rate-adaptive mode). Scanning for an intrinsic rhythm is repeated after an additional 180 cycles.




**Reaction to vasovagal syncopes and carotid sinus syndrome**

The scan rate hysteresis can be used in conjunction with the repetitive rate hysteresis to treat patients with vasovagal syncopes and carotid sinus syndrome of a primarily cardioinhibitory type.

The following programming is recommended for this purpose:

| Parameter | Recommended programming |
|---|---|
| Basic rate | Increased value (e.g. 90 ppm) |
| Rate hysteresis | So that the hysteresis rate at rest is always lower than the intrinsic rhythm (e.g. -50) |
| Scan rate hysteresis | Enabled with the number of cycles set according to the patient's condition |
| Repetitive rate hysteresis | Enabled with a low number of cycles |

basta un evento e termina con il primo evento mancante favorisce ritmo spontaneo in presenza di ritmo stabile mantiene un ritmo presente allungando i cicli cardiaci temporaneamente

obiettivo: x tutte è quello di mantenere il ritmo spontaneo

This program will inhibit the pacemaker until bradycardia episodes occur. If the rate drops due to an attack, the pacemaker will pace at the hysteresis rate for the set number of repetition cycles (the confirmation period).

The pacemaker will switch to the higher intervention rate to prevent possible syncope only if a spontaneous rhythm does not occur during the confirmation period, which should be set as short as possible.

The pacemaker will scan for a spontaneous rhythm every 180 cycles (scan rate hysteresis) to avoid long pacing phases. If the attack has been terminated by that time, the pacemaker will be inhibited; otherwise, it will repeat the scan every 180 cycles.

**Note:** These patients should only be treated with a DDD(R) system to exploit the contribution of the atrium to ventricular filling and to overall hemodynamics as much as possible during such attacks.

22

# RATE HYSTERESIS

obiettivo preservare il ritmo spontaneo, evitare scompenso cardiaco

rate hysteresis è definito come la differenza dall'intervallo base

Dopo un evento sentito, il PM non aspetta ovviamente la fine dell'$I_3$ per stimolare ma per tutta la durata dell'intervallo di isteresi. Se l'evento c'è allora non introduce nuovamente l'intervallo base, se non c'è ritorno all'intervallo base

DDD DDT VDD AAT AAI → evento sentito atrio

DDI VVI VVT VDI → " " ventricolo

Nel caso di rate adaptive, l'isteresi rimane costante, mentre la ~~frequenza~~ int. d'isteresi si adatta all'intervallo base variabile con le sensore.

# REPETITIVE RATE HYSTERESIS

obiettivo: preservare il ritmo spontaneo ed evitare la stimolazione durante le pause post-extrasistole.

Quando sono sicuro di avere ritmo spontaneo, durante la stimolazione del PM alla frequenza d'isteresi non torno subito alla frequenza dell'intervallo base ma permetto al PM di stimolare ad una frequenza più bassa per un po' di volte. Se alla fine di queste 3-4 volte vedo ritorno di ritmo spontaneo posso di nuovo alla frequenza base altrimenti permetto al cuore di stimolare spontaneamente anche ad una frequenza più bassa

(1) Nella R.H basta un solo battito spontaneo per attivare l'isteresi della frequenza, nella R.R.H. ce ne vogliono molti

(2) Nella R.H se non avviene la stimolazione spontanea per un solo battito torno all'intervallo base. Nella R.R.H. il PM continua a stimolare alla frequenza d'h. prima di tornare all'intervallo Base

Se l'intervallo AV è troppo lungo il rimpiazzamento dei ventricoli non è efficace

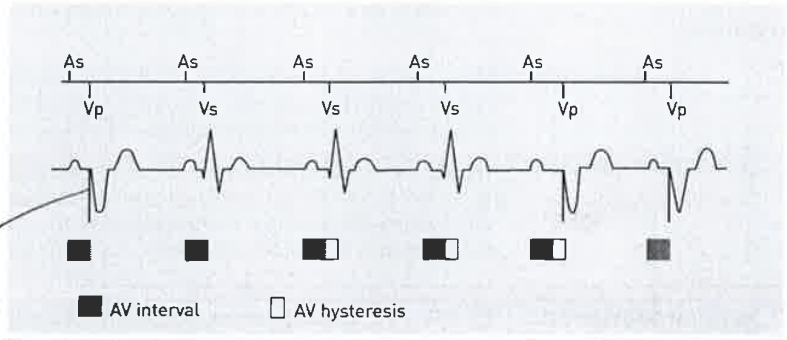


## AV Hysteresis

Cerco di evitare la conduzione spontanea tra atrio e ventricolo

**Purpose** AV hysteresis can be programmed to a low, medium, or high setting to promote intrinsic AV conduction.

dopo un ciclo in cui ho un evento spontaneo estendo l'intervallo AV in modo tale da aspettare di vedere attività spontanea fino a quando un'attività ventricolare manca, quindi do uno stimolo e al ciclo successivo interrompo l'isteresi




stimolo perché non ho stimolo ventricolare

**Description** In the case of activated AV hysteresis, the AV delay is extended by a defined time period after sensing an intrinsic ventricular event. The long AV delay remains intact as long as an intrinsic ventricular activity is measured. The short AV delay interval without extension by the hysteresis value then follows after repeated ventricular pacing.

**CAUTION**

If AV hysteresis is enabled along with the algorithm for detecting and terminating pacemaker-mediated tachycardias (PMT management), the variations in the AV delay for detection and termination of a PMT have priority over any possible simultaneous activation of the AV hysteresis.

## AV Repetitive Hysteresis

in presenza di un certo numero di cicli successivi in cui vi è conduzione intrinseca si ripristina alla mancata conduzione

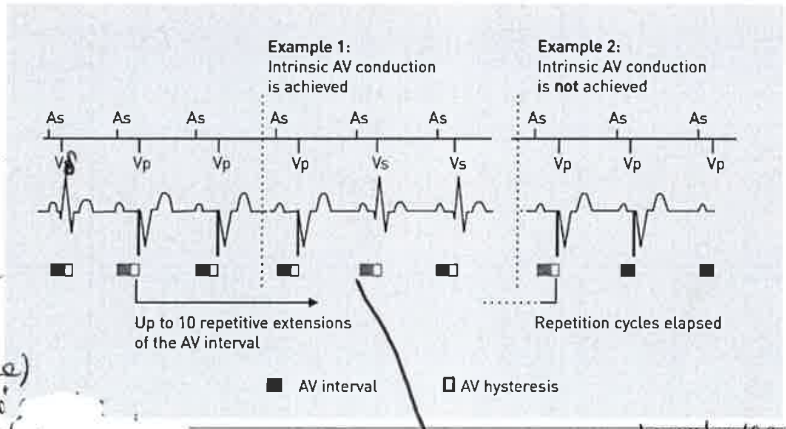
**Purpose** The AV repetitive hysteresis reduces pacing when existing intrinsic activity within the extended AV delay is suppressed by occasional paced events.

l'intervallo esteso viene mantenuto per un certo n° di cicli programmati

**Description** With active AV repetitive hysteresis, the AV delay is extended by the defined hysteresis value after the sensing of an intrinsic ventricular event.

In contrast to normal AV hysteresis, once the ventricular paced event occurs, the long AV delay for a programmed number of cycles remains intact. If an intrinsic activity occurs during one of these repetitive cycles, the long AV delay remains intact. Only when the repetitive cycles have elapsed without spontaneous AV conduction does the pacemaker switch back to the short AV delay.

Non è richiesto che ci sia stata conduzione intrinseca per 180 cicli




SCANSIONE DI ISTERESI AV: cerca di mantenere in una condizione di conduzione intrinseca un atrio in cui la conduzione intrinseca non è presente. Ha loop solo quando la conduzione intrinseca

Dopo 180 cicli l'intervallo AV viene esteso (se è mancata la cond. intrinseca) per un certo n° di cicli programmabili per vedere se si instaura spontanea. Se salta fuori la cond. intrinseca viene mantenuto esteso l'AV a seconda che sia stata attivata isteresi dell'atrio o ventricolare

→ guardare p 81

qui atrio il catetere

Se all'interno del n° di cicli programmato non vi è attività volontaria si torna all'intervallo AV normale

24

## AV HISTERESIS

Cerco di evitare la conduzione spontanea tra atrio e ventricolo facendo attenzione ad evitare di allungare troppo AV in quanto provocherebbe un'inefficacia del riempimento dei ventricoli

Dopo un ciclo in cui ho un evento ventricolare spontaneo estendo l'intervallo AV in modo tale da aspettare che ci sia la stimolazione spontanea. Fino a quando ho $V_S$ AV rimane allungato se no interrompo l'isteresi.

## AV REPETITIVE HYSTERESIS

Se dopo aver esteso l'intervallo AV non ho una conduzione spontanea ritorno all'intervallo AV base ma continuo ad avere alcuni intervalli AV con isteresi se vi è $V_S$ allora continuo con l'isteresi di AV se dopo alcuni eventi $V_P$ continuo ad averli torno alla stimolazione all'intervallo AV base.

## SCANSIONE D'ISTERESI AV

Dopo 180 cicli in cui ho AV base estendo AV all'isteresi per vedere se riesco a tornare a conduzione spontanea. Se ho la conduzione allora attivo o la AV ripetitiva o l'isteresi normale

## NEGATIVE AV HYSTERESIS

obiettivo: evitare la conduzione spontanea nei pazienti con scompenso cardiaco congestizio

Quindi AV è minore di quello normale.

Posso applicare anche l'isteresi negativa ripetitiva di AV.

## Setting AV Hystereses

**Purpose of positive hysteresis**

The positive AV hysteresis function serves to sustain the patient's spontaneous AV conduction as long as possible, thereby guaranteeing a natural contraction sequence. This prevents any unnecessary pacing in the ventricle.

**Purpose of negative hysteresis**

The negative AV hysteresis function supports ventricular pacing and allows the least possible amount of conductions of the atrial intrinsic rhythm.

This may be necessary particularly for patients with hypertrophic obstructive cardiomyopathy (HOCM) or for patients with congestive heart failure who receive resynchronization therapy

**Description**

- For positive AV hysteresis, the programmed AV delay is extended by a defined value and can be performed with various preference settings.
- With a ventricular sensed event (Vs), a negative AV hysteresis decreases the AV delay and thereby promotes ventricular pacing.

**Note:** IRSplus and AV hystereses cannot be activated if `Vp suppression` has been activated.

26

## How Ventricular Pacing Suppression Works

**Overview**

The following topics are described within this segment:

- Activation of Vp suppression
- Mode of functioning
- Switching from DDD(R) to ADI(R)
- Switching criterion and Vs continuity search
- The Vs continuity search triggered by a single Vs
- Vs continuity search triggered by a timing interval
- Intelligent search
- ADI(R) mode
- Switching from ADI(R) to DDD(R)
- Switching criterion: 2 seconds without Vs
- Switching criterion: 2 consecutive cycles without Vs
- Switching criterion: Programmable number X of 8 cycles without Vs
- Summary
- Vp suppression and mode switching
- Statistics recordings of Vp suppression
- Vp suppression and high rates
- Vp suppression interactions with other functions and actions

**Activation of Vp suppression**

The Vp suppression function is activated if the mode DDD-ADI or DDDR-ADIR is selected.

**Mode of functioning**

Vp suppression supports intrinsic AV conduction by only pacing in the ventricle if intrinsic AV conduction becomes unstable or stops.

If there is intrinsic AV conduction, the function works in a mode similar to ADI(R).

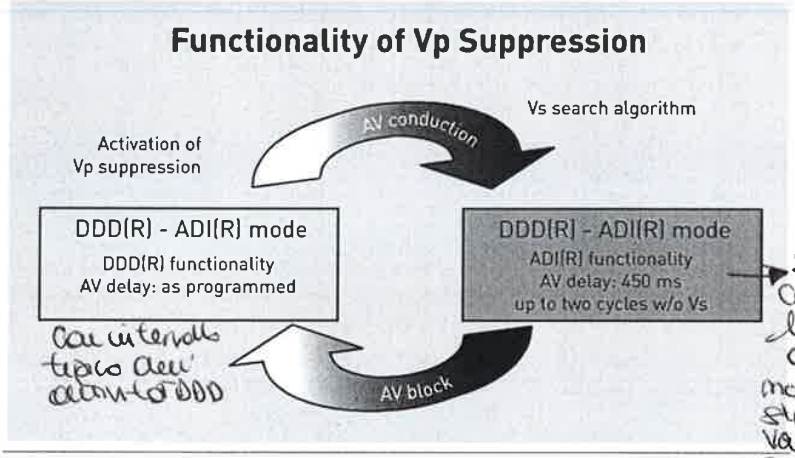
If intrinsic AV conduction stops or becomes unstable, the function paces in DDD (R) mode with the programmed AV delay in the ventricle.

Automatic mode switching between these two modes provides for maximum intrinsic optimization without doing damage to the patient.

Scan algorithms with a programmed schedule test intrinsic AV conduction and the AV delay is extended to 450 ms.

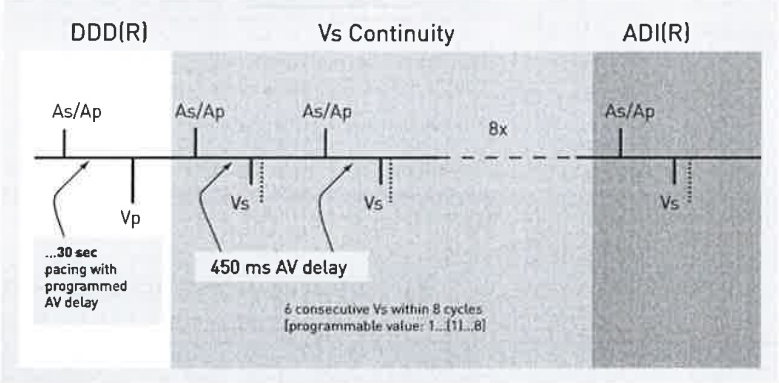
The ADI(R) mode - according to the NBG pacemaker code - describes precisely what the device does in this state. Thus, as opposed to the AAI(R) mode, sensing is also possible in the ventricle in order to switch to the DDD(R) mode and pace in the ventricle in the case of ventricle pauses or unstable rhythms.

### Functionality of Vp Suppression



**Vs continuity search triggered by a timing interval**

If the DDD(R)-ADI(R) mode has been set and the device paces with the programmed AV delay in the ventricle, then the initial Vs continuity search begins 30 s after removing the programming head.




The Vs continuity search runs in the same way within the programmed AV delay as the search triggered by a single Vs.

The condition for switching to the ADI(R) mode is met if the programmed number of Vs is consecutively sensed within 8 cycles.

**Intelligent search**

The intelligent search serves to avoid frequent scan cycles for patients who have no intrinsic activity.

The reason for this is that some patients become symptomatic if the device paces with a long AV delay.

Every time the Vs continuity search is unsuccessful, the timing interval for starting the search is doubled until a limit of 128 min. is reached. Then the Vp suppression function will only search every 20 hours for intrinsic AV conduction. The scan interval is set to 20 hours instead of every 24 hours so that the search is initialized at different times of day. The search is carried out at different times of day and night in a 6-day cycle.

The Vp suppression function does not deactivate itself entirely on its own.

**Intelligent search time schedule**

se non c'è contributo ↓

ripeto il test ogni

30 sec → 1 min → 2 min → 4 min → .... → 128 min → 20 h

**ADI(R) mode**

The device always works in ADI(R) mode if there is stable intrinsic activity.

If the device works in ADI(R) mode according to NBG nomenclature, then pacing is only performed in the atrium **(A)**. Sensing takes place in both chambers **(D)**, but atrial pacing is inhibited **(I)** if the intrinsic rate is higher than the basic rate or the rate specified by the sensor **(R)**.

While working in ADI(R) mode, no ventricular pacing is carried out. If no ventricular sensing occurs within two cardiac cycles or within 2 seconds, then it switches to DDD(R) mode.

While the device is working in the ADI(R) mode, sensing is performed in the atrium and ventricle. The AV delay is 450 ms and is not followed by a ventricular stimulus.

30

→ lo stimolo è stato efficace ed ha innescato la depolarizzazione delle cellule stimolate

## Atrial Capture Control - Overview → controllo l'efficacia

soglia di stimolaz. varia nel tempo

**Overview**

- Objective of atrial capture control
- Function
- Advantages

**Objective of atrial capture control**

Lead aging, changes to the medication, lead dislodgement and pathological changes can result in changes to the pacing threshold.

Automatic algorithms permit follow-ups to be carried out as efficiently as possible. Automatic measurement of the ventricular threshold and the corresponding automatic adaptation of the ventricular pacing amplitude are functions, which have already been used for many years in clinical practice.

This type of automatic algorithm is thus advantageous for measurement of the atrial threshold and the corresponding adaptation of the atrial amplitudes.

**Function**

The dual-chamber systems in this device line dispose of an algorithm for atrial capture control, which is based on periodical observation and differentiation of atrial signals. The algorithm automatically measures the atrial threshold at a defined time and adapts the pacing amplitude when needed.

**Advantages**

The following advantages arise from the use of atrial capture control:

- **Remote follow-up:**

  Follow-up can be performed as remote follow-up with BIOTRONIK Home Monitoring. The atrial capture control function is one of the requirements for this.

- **Safety:**

  The atrial amplitude is automatically adapted to increased atrial thresholds, so that atrial exit blocks are avoided.

- **Longevity:**

  The lowest atrial pacing amplitude value is determined by atrial capture control. It is automatically adapted to the current atrial threshold in each case and a safety margin is added. Low values for the atrial pacing amplitude increase the service life of the device.

se perdo una cattura dell'atrio non succede nulla, ma se perdo quella del ventricolo è un problema → 2 algoritmi diversi

32

Se facessi il test in modalità DDD rischierei la conduzione retrograda

**Searching for the pacing threshold**

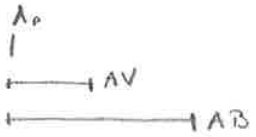
Mode and AV delay during the test

- DDI mode: → modalità di servizio

  Pacing in the DDI mode prevents tracking of retrograde conducted P waves, which can occur if the atrial stimulus response is lost during the pacing threshold test.
  In the DDD mode, retrograde conducted P waves can trigger pacemaker-mediated tachycardias. Therefore, the test is carried out in DDI mode.

- AV delay = 50 ms

  After the AV delay of 50 ms, ventricular pacing is carried out, starting an atrial blanking of 150 ms. During blanking, the cardiac pacemaker does not evaluate the atrial signals for the test.
  To allow sensing of the atrial rhythm as early as possible and prevent retrograde conduction, the AV delay has to be as short as possible. This ensures that intrinsic atrial events are not blanked in the atrial channel.




Se c'è risposta dell'atrio stimolo l'atrio, se quella del ventricolo non la vedo

Si fanno 5 tentativi per ogni valore di ampiezza, devo avere 2 eventi su 5 per decidere che quella è la soglia di stimolazione temporanea. Da quel momento decido a scendere a passi di 100mV fino a quando con perdo 2 eventi su 5, a quel punto torno al valore precedente che è la mia soglia

**Pacing threshold search using amplitude reduction**

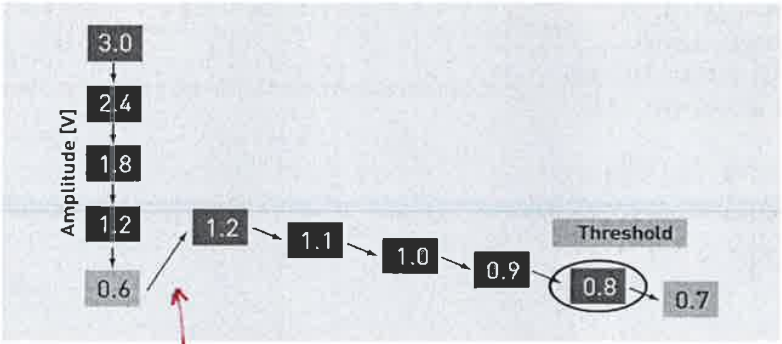
- The pacing threshold search begins at the programmed start amplitude (default setting: 3.0 V). The amplitude is reduced here in 0.6 V increments, until 2 intrinsic atrial events are sensed within 5 cycles (2 of 5).
- After the first loss of stimulus response (2 of 5), the device switches back to the amplitude, at which the last stimulus response took place, in order to perform a more detailed search.
- The test amplitude is decreased in increments of 0.1 V until the device detects a loss of 2 of 5 possible stimulus responses for the second time.

  This completes the pacing threshold search.

Below 0.6 V, the search is always performed in 0.1 V increments.

The criterion 2 of 5 was selected because statistically, at least 2 events within 5 cycles can be sensed outside the far-field protection interval.

Start amplitude: 3.0 V; amplitude reduction: 0.6 V increments; loss of stimulus response at 0.6 V; beginning of detailed search at 1.2 V; amplitude reduction: 0.1 V increments; loss of the stimulus response at 0.7 V; **pacing threshold at 0.8 V**




Se non ho eventi risalgo a 1.2 Volt! Non scendo a 0.5V!!!

**Automatic Active Capture Control**

- The atrial pacing amplitude is adapted by adding the programmed safety margin (default setting 1.0 V, adjustable) to the measured pacing threshold.
- If no atrial pacing threshold test could be carried out (e.g., at an intrinsic rate > 108 bpm), the current atrial amplitude remains valid.
- If atrial capture control is deactivated (e.g., in the case of interferences of a unipolar lead), the atrial amplitude is calculated by adding the test output amplitude and the safety margin. Default setting: 3.0 V + 1.0 V = 4.0 V.

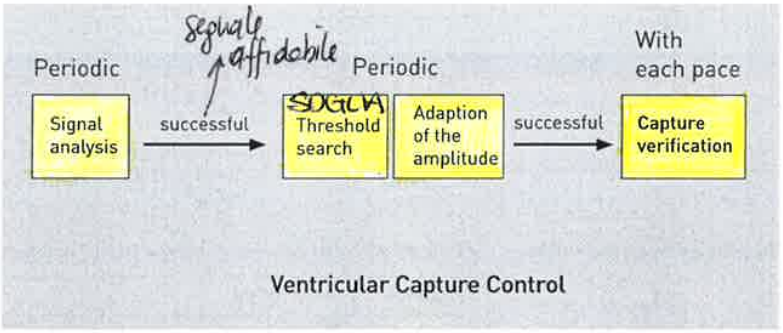
**Note:**
If atrial capture control is deactivated, an error message is displayed in the Follow-up window and an event message is generated for BIOTRONIK Home Monitoring.
Unsuccessful measurements of atrial capture control are shown in the Home Monitoring statistics as gaps.

**Programming suggestions**

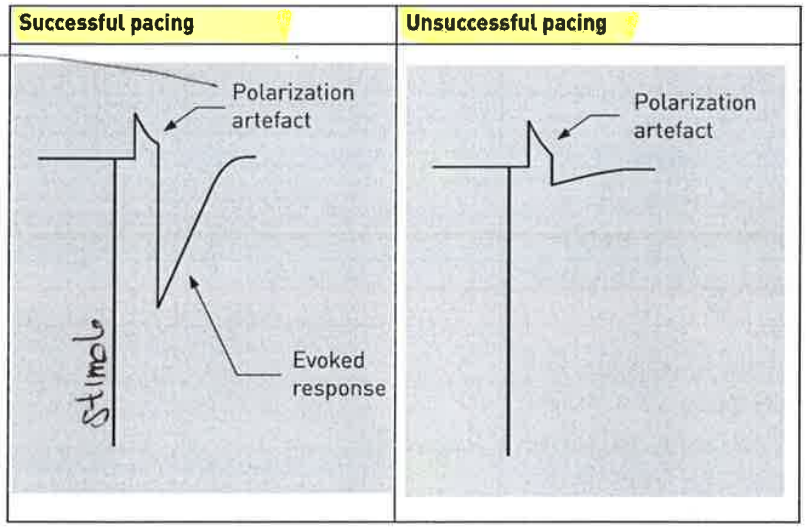
- The value of the Threshold test start parameter does not influence the success of the test (as opposed to ventricular capture control), but reduction makes it several seconds faster.
- The test is repeated daily at the programmed time.

**Note:** Make sure there is a sufficient difference between the threshold and the value of the threshold test start parameter, so that pacing threshold changes can be monitored following implantation.

**Overview of the algorithm's components**




The algorithm is based on the comparison of the signals from the evoked response and the polarization artifact.




**Characteristics**

The function comprises of the following characteristics:

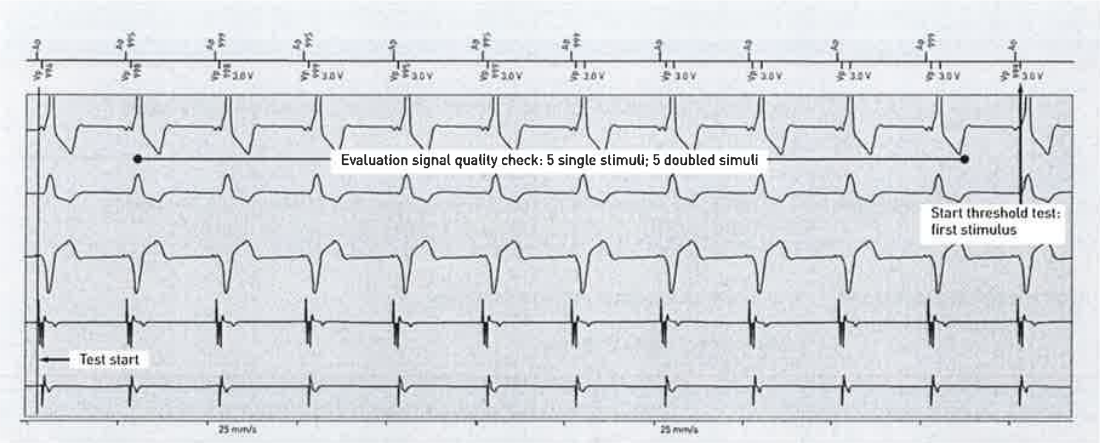
- The function periodically measures the pacing threshold, automatically adjusts the pulse amplitude and offers a programmable safety margin.
- The function checks the effectiveness of every ventricular pacing pulse on a beat-to-beat basis and implements a back-up pulse in the case of an ineffective stimulus (non-capture).
- The differences in the signal morphology and the evoked response and the polarization artifact are used to differentiate between effective and ineffective pacing.

**Manual/automatic determination**

- As the manual method of determining the pacing threshold occurs at long intervals (e.g. every 12 months), a large safety margin must be selected in order to ensure an effective pacing.
- An automatic method, which continually checks the efficiency of pacing and periodically determines the pacing threshold (e.g. every 12 hours), can manage with a smaller safety margin, as the pacing amplitude is continuously adjusted to the demand. A smaller safety margin may lead to less power consumption and an extended longevity of the device.

verifica la risposta sul singolo stimolo l'intervallo dello ventricolare è sempre uguale

**Example: Checking signal quality, analysis of evoked responses**




**Possible scenarios during signal analysis**

| If... | Then... |
|---|---|
| after initial activation of ventricular capture control, signal analysis is not completed successfully, | the function is immediately deactivated and the pacing amplitude is set to the threshold test start amplitude value. By changing parameters (see note above), the signal quality can be changed so that analysis is permanently successful. |
| after initial activation, signal analysis is completed successfully, but subsequently completed without success, | the function is suspended and the pacing amplitude is set to a safe value. This value is composed of the last measured threshold + maximum safety margin of 1.2 V. Signal analysis is performed again at the next programmed time. The procedure is carried out up to three times. |
| the third consecutive signal analysis remains unsuccessful, | the function will be deactivated and the pacing amplitude set to a safe value (threshold test start amplitude + 1.2 V). Afterwards, the ventricle capture control can only be manually reactivated with the programmer. |

40