Characterization of the 16 Blanking Periods of the Medtronic GEM DR Dual Chamber Defibrillators

S. Serge Barold and Fernando Cantens
From the Electrophysiology Institute, Broward General Hospital and Medtronic Inc., Ft. Lauderdale, Florida, USA

Abstract. We determined the blanking periods of the Medtronic GEM DR dual chamber defibrillators by using a simulator to deliver signals mimicking arrhythmias into external devices programmed to various settings. The blanking periods for the tachycardia and bradycardia functions were measured in the atrial and ventricular channels after a paced atrial event, sensed atrial event, paced ventricular event and sensed ventricular event, adding to a total of 16 blanking periods. Our findings complement the incomplete or unclear specifications published by the manufacturer. Accurate knowledge of blanking periods is essential for the interpretation of device function.

Key Words. defibrillator, pacemaker, dual-chamber defibrillator, blanking period, refractory period

Introduction
The introduction of dual chamber defibrillators (DCD) has added new complexity to the understanding of device blanking and refractory periods [1,2]. The Medtronic GEM DR I and II DCDs may according to circumstances, exhibit either common or separate blanking periods for antibradycardia pacing and antitachycardia function or defibrillation (brady blanking and tachy blanking respectively). We investigated the duration of the brady and tachy blanking periods (BP) of the Medtronic GEM DR DCDs because the values in the technical manuals were either unclear or incomplete [3,4].

Methods
We used a standard simulator to introduce a variety of arrhythmias into several external GEM DR I and II DCDs sequentially programmed to various combinations of parameters. Sixteen BPs were determined: 8 brady and 8 tachy BPs. The absence of a BP after a paced or sensed event was assigned a value of zero.

Atrial channel
4 brady BPs and 4 tachy BPs were measured after As (atrial sensed event), Ap (atrial paced event), Vs (ventricular sensed event), and Vp (ventricular paced event).

Ventricular channel
4 brady BPs and 4 tachy BPs were also measured after As, Ap, Vs and Vp.

A refractory period was defined as a timing cycle during which sensing can occur but the data are not used to initiate an AV delay in the atrial channel or a lower rate/atrial escape interval in the ventricular channel. In Medtronic dual chamber pacemakers a refractory sensed event is depicted by AR in the atrial channel and VR in the ventricular channel. Consequently we looked for these AR and VR markers and their timing during a variety of injected arrhythmias into the external devices.

Results
We established the duration of all the 16 BPs as outlined above. Some of our determinations were at variance with the published specifications by the manufacturer. Our results are shown in Table 1 and diagrammatically in Figures 1–7.

1. The tachy function has only BPs but no refractory periods.
2. The brady function has both BPs and refractory periods. The refractory periods are restricted to the atrial channel.
3. BPs may or may not be equal or common for both tachy and brady functions. Only the atrial channel has different BPs for the tachy and the brady functions.
4. No VR markers were observed in the ventricular channel. The brady and tachy functions of the GEM DCDs have no ventricular refractory period in contrast to Medtronic dual chamber pacemakers where a refractory sensed event (VR) can occur. The duration of the ventricular BP after Vs is important to evaluate the presence of double sensing of the QRS by the

Address for correspondence: S. Serge Barold, MD. 6237 NW 21st Court, Boca Raton FL 33496.
E-mail: sbarold@aol.com

Received 28 June 2000; accepted 6 December 2000
ventricular channel. The duration of the ventricular paced blanking period is important to prevent T wave oversensing by the ventricular channel.

5. It was possible to program the atrial channel with a common postatrial paced BP extending beyond Vs and beyond the very short cross-chamber atrial BP initiated by Vp. This was more prominent with the GEM I DCD where the BP after Ap or the postpacing paced BP is programmable to a maximum of 440 ms (Figs. 2, 3 and 8).

6. Cross-chamber BPs could not be determined accurately because of their short duration. The cross-chamber BPs after Ap in the ventricular channel and after Vp in the atrial channel were about 30 ms. No cross-chamber BPs were detected after atrial or ventricular sensing.

7. In patients with implanted DCDs programmed to pace in the dual chamber mode, all sensed atrial events are represented by As markers only during short periods of VVI pacing after a

Table 1. Blanking and refractory periods of the GEM DR dual chamber defibrillator

<table>
<thead>
<tr>
<th></th>
<th>Atrial Tachy BP</th>
<th>Atrial Brady BP</th>
<th>Atrial Refractory</th>
<th>Ventricular Tachy BP</th>
<th>Ventricular Brady BP</th>
<th>Ventricular Refractory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ap</td>
<td>200–440 sec</td>
<td>200–440 sec</td>
<td>If AVI &gt; BP started by Ap</td>
<td>30 sec</td>
<td>30 sec</td>
<td>0</td>
</tr>
<tr>
<td>As/AR</td>
<td>100 sec</td>
<td>100 sec</td>
<td>If AVI &gt; BP started by As</td>
<td>0 sec</td>
<td>0 sec</td>
<td>0</td>
</tr>
<tr>
<td>Vp</td>
<td>30 PVAB</td>
<td>150–440 sec</td>
<td>PVARP</td>
<td>120 sec</td>
<td>120 sec</td>
<td>0</td>
</tr>
<tr>
<td>Vs</td>
<td>0 PVAB</td>
<td>150–440 sec</td>
<td>PVARP</td>
<td>120 sec</td>
<td>120 sec</td>
<td>0</td>
</tr>
</tbody>
</table>

All values are in ms. Tachy = Tachycardia function, Brady = Bradycardia function, Ap = Atrial paced event, As = Atrial sensed event, AR = Atrial Refractory sensed atrial event, Vp = Ventricular paced event, Vs = Ventricular sensed event, AVI = Atrialventricular interval, * = Common blanking period, a = GEM DR I, b = GEM DR II, c = value for GEM DR I. For the GEM DR II, the value is 200–440 ms. PVARP = Postventricular atrial refractory period, PVAB = postventricular blanking period.

Fig. 1. Diagrammatic representation of BPs of the Gem DR I DCD. The Ap-Vp interval is 200 ms and equal to the minimum value of the postpacing paced common BP depicted by the number 1. 2 = Cross-chamber tachy BP, 3 = Postventricular atrial brady BP. Ap = atrial paced event, Vp = ventricular paced event, BP = blanking period, DCD = dual chamber defibrillator.

Fig. 2. Diagrammatic representation of BPs of the Gem DR I DCD. The Ap-Vp interval is shorter than the relatively long programmed postatrial paced common BP which is depicted by the number 1. Note how the postatrial BP extends beyond 2 into 3. Same format as in Figure 1.

Fig. 3. Diagrammatic representation of BPs of the Gem DR I DCD. The Ap-Vs interval is shorter than the postatrial paced common BP. Note how the postatrial paced common BP extends beyond Vs into 3. 6 = Ventricular sensed common BP, Vs = ventricular sensed event. Same format as in Figure 1.