Comparative efficacy of transvenous cardioversion and pacing in patients with sustained ventricular tachycardia: a prospective, randomized, crossover study

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ABSTRACT We performed a prospective, randomized crossover study to evaluate the comparative efficacy of transvenous cardioversion and rapid ventricular pacing for termination of induced ventricular tachycardia in patients with spontaneous ventricular tachycardia and organic heart disease. Sixty-two episodes of ventricular tachycardia were induced in 15 patients, mean age 60 ± 10 years, during electrophysiologic studies. All patients underwent a preselected electrical therapy protocol in a randomized crossover sequence. Transvenous cardioversion was performed by an incremental protocol of three sequential shocks (0.5, 1.1, and 2.7 J). Six asynchronous sequential bursts of rapid ventricular pacing (10 and 15 paced stimuli at 90%, 75%, and 65% of ventricular tachycardia cycle length) were used. Mean cycle length of ventricular tachycardia for the study population was 391 ± 85 msec. The morphology of the tachycardia was left bundle branch block in 27, right bundle branch block in 32, and indeterminate in three. Characteristics of ventricular tachycardia terminated by the two techniques were comparable. Rate of success for termination of tachycardia with the two methods was also comparable (transvenous cardioversion 83%, rapid ventricular pacing 80%; p > .1) and these responses were concordant in 78%. The modes of termination of ventricular tachycardia were similar. The incidence of acceleration of ventricular tachycardia per episode with these preselected protocols was also comparable (transvenous cardioversion 11%, rapid ventricular pacing 6%; p > .2). Transient supraventricular tachyarrhythmias were more frequent after transvenous cardioversion (23%) than after rapid ventricular pacing (3%). Significant patient discomfort occurred only after transvenous cardioversion (incidence of 57%). We conclude that transvenous cardioversion and rapid ventricular pacing have comparable and usually concordant efficacy for termination of ventricular tachycardia. Transvenous cardioversion results in a higher incidence of postcardioversion arrhythmias and poorer patient tolerance than does rapid ventricular pacing.


TERMINATION of sustained ventricular tachycardia by the use of different techniques of internal electrical cardiac stimulation has been reported.1 The comparative efficacy and safety of each technique and its potential role in clinical practice remain to be defined. Bursts of rapid ventricular pacing have been used to terminate sustained ventricular tachycardia in man for over a decade.2 More recently the efficacy of intracavi-
tachycardia. Patients were undergoing clinically indicated electrophysiologic studies (EPSs). For purposes of this study “recurrent” was defined as three or more spontaneous episodes and “sustained” was defined as ventricular tachycardia of greater than 30 sec duration or requiring termination because of hemodynamic compromise. (2) They had not suffered recent (less than 30 days) myocardial infarction. (3) They had undergone reproducible induction of sustained ventricular tachycardia during EPS. (4) They gave informed consent for the cardioversion and electrophysiologic procedure.

Fifteen consecutive consenting patients (12 men and three women) with ages ranging from 36 to 73 (mean 60 ± 10) years and satisfying all entry criteria were enrolled in this study. Twelve patients had coronary artery disease. Of these, four had experienced a prior myocardial infarction and one had undergone coronary artery bypass surgery and aortic valve replacement. Two patients had congestive cardiomyopathy and one had documented mitral valve prolapse. The mean left ventricular ejection fraction of the study population ranged from 17% to 50% (mean 27 ± 13%). Thirty-five EPSs were performed in these patients (2.3 per patient). At the time of EPS, eight patients were undergoing control and 14 patients were undergoing serial drug EPS.

Study design. Patients were prospectively randomized into two study groups (see figure 1). All patients underwent EPS and programmed electrical stimulation for induction of sustained ventricular tachycardia. After its induction, electrical termination of the sustained ventricular tachycardia was attempted. Group A patients were initially treated with a preselected incremental transvenous cardioversion protocol and group B patients were initially treated with a preselected rapid ventricular burst pacing protocol. If termination of ventricular tachycardia was accomplished with this initial treatment the arrhythmia was then reinduced by the same technique and the other mode of electrical therapy was applied. Thus, group A patients were subsequently treated with the preselected rapid ventricular pacing protocol and group B patients subsequently underwent the preselected transvenous cardioversion protocol. If ventricular tachycardia could not be terminated with the initial selected mode of electrical treatment, the other mode of electrical treatment was applied. If ventricular tachycardia could not be terminated by either form of electrical treatment, pharmacologic interventions and/or transthoracic electrical cardioversion were used for termination of arrhythmia.

Electrophysiologic procedures. Patients underwent the initial EPS in the drug-free, nonsedated, postabsorptive state. Multipolar catheters were inserted by the standard percutaneous introducer techniques. A Medtronic 6880 temporary electrode catheter was used for transvenous cardioversion and pacing. This is a tripolar electrode catheter with a pair of bipolar electrodes at its distal end that are used for electrogram sensing and pacing. During cardioversion the electrodes become electrically common and form the cathode. A proximal electrode 125 mm from the distal electrodes functions as the anode during cardioversion. Intracardiac electrograms were monitored at the high and midnight atrium, the His bundle, and the right ventricular apex. Surface electrocardiographic leads I, aVF, and V₁ were recorded simultaneously. Arterial blood pressure was monitored by an indwelling femoral artery sheath connected to a Statham P23 transducer. A multichannel display recorder (Electronics for Medicine VR-16, White Plains, NY) was used to amplify and display the electrograms. Hard copy recordings were obtained at paper speeds of 50 to 250 mm/sec. Programmed electrical stimulation and rapid pacing were performed with a programmable stimulator (Bloom Associates, Ltd., Narbeth, PA) that delivered rectangular pulses of 1 or 2 msec duration at twice diastolic threshold. Programmed stimu-

lulation was performed with a standard protocol from our laboratory, as previously described. Transvenous cardioversion was performed with a Medtronic 5350 external cardioverter/defibrillator. This is a battery-operated external device that is capable of delivering truncated exponential electrical discharges with graded energies ranging from 0.03 to 28.0 J. Different energy waveforms controlled by tilt settings can be selected. The cardioverter/defibrillator is capable of synchronization with the patient’s QRS complex. The modes of operation of this device have been previously described in detail. The external cardioverter/defibrillator was interfaced with the programmable stimulator for rapid application of both forms of electrical therapy.

After sustained ventricular tachycardia was induced, rapid ventricular pacing or transvenous cardioversion, depending on the randomization status, was first attempted. The entire protocol was attempted unless successful termination of ventricular tachycardia was achieved or tachycardia accelerated or degenerated into ventricular fibrillation when it was aborted and the arrhythmia was terminated by transthoracic cardioversion or defibrillation. Subsequently patients were restudied one or more times during serial electrophysiologic testing while they were on antiarrhythmic drugs. The entire randomization process was repeated for serial studies to avoid selection bias. However, in view of the need for repeated induction and termination of hemodynamically unstable ventricular tachycardia in this study, the multiple inductions and terminations required to establish reproducibility of each technique were not performed.

Electrical therapy protocol. Preselected incremental electrical treatment protocols were used for transvenous cardioversion and rapid ventricular pacing. The transvenous cardioversion protocol consisted of three synchronized sequential shocks of 0.5, 1.1, and 2.7 J. All shocks were delivered at a tilt of 63%. The rapid ventricular pacing protocol consisted of two asynchronous trains of 10 and 15 paced stimuli applied sequentially at 90%, 75%, and finally 65% of the cycle length of the induced ventricular tachycardia.

Study parameters. The parameters analyzed in this study were demographic factors (age, sex), disease and functional status, standard electrocardiographic intervals (RR interval, PR interval, QRS duration, corrected QT interval), intracardiac intervals, left ventricular ejection fraction, characteristics of ventricular tachycardia (cycle length, morphology, induction mode), ventricular effective refractory period, lead threshold, and the presence or absence of antiarrhythmic drugs. Tolerance of each form of therapy was classified on the basis of the patient’s subjective perception of the procedure as painless or minimally uncomfortable, moderately painful but tolerable, or severely and intolerably painful.

Results

Comparison of study groups. The study design exposed all patients to both types of electrical therapy in a randomized fashion. Thus there was no difference in the demographic, disease, functional, or electrophysiologic characteristics of the study groups exposed to the two techniques. In addition, the characteristics of the induced ventricular tachycardia (morphology, frontal plane axis, and cycle length) were similar for both forms of treatment (table 1). The randomized study groups A and B were also comparable with respect to these factors, as shown in table 2.

Clinical efficacy of rapid ventricular pacing and transvenous cardioversion. Sixty-two episodes of ventricular
THERAPY AND PREVENTION–ARRHYTHMIA

TABLE 1
Characteristics of arrhythmias in patients with sustained ventricular tachycardia (VT) before application of transvenous cardioversion and rapid ventricular pacing

<table>
<thead>
<tr>
<th></th>
<th>Transvenous cardioversion</th>
<th>Rapid ventricular pacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>VT characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of episodes</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Control EPS</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Drug EPS</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Mean cycle length (range)</td>
<td>392 ± 93 msec (230–620)</td>
<td>397 ± 87 msec (280–620)</td>
</tr>
<tr>
<td>QRS complex morphology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBBB</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>LBBB</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

RBBB = right bundle branch block; LBBB = left bundle branch block.

tachycardia were induced in 15 patients during the course of this study. Each mode of electrical therapy was applied to 35 episodes of ventricular tachycardia. Eight episodes were unresponsive to attempted termination with the first mode of electrical therapy and the patients were subsequently exposed to the second mode of electrical therapy.

Twenty-nine episodes of ventricular tachycardia were successfully terminated with transvenous cardioversion, with an overall efficacy rate of 83%. Fifty-five transvenous cardioversion shocks were required (mean 1.6 per episode of tachycardia). Rapid ventricular pacing terminated 28 episodes, with an overall efficacy rate of 80%. A total of 85 attempts at rapid ventricular pacing were required (mean 2.4 per episode of ventricular tachycardia). Figure 1 illustrates the electrophysiologic effects of termination of ventricular tachycardia with both methods in the same patient during an electrophysiologic procedure. Induced ventricular tachycardia of an identical morphology and cycle length was immediately and rapidly terminated by a transvenous cardioversion shock of 1.08 J (figure 1, A) and rapid ventricular pacing (figure 1, B) at 396 msec (90% of ventricular tachycardia cycle length). Successful pacing modes and transvenous cardioversion shock energies in this study group are listed in table 3. Rapid ventricular pacing was successful at 90% and 75% of ventricular tachycardia cycle length at both stimulus train durations. Transvenous cardioversion was often successful at 0.5 J, but intermediate and high energies were needed in some patients. There was a high degree of concordance with respect to successful interruption of ventricular tachycardia by the two methods (figure 2), with a total of 25 of 32 successfully terminated episodes (78%) of ventricular tachycardia being terminated by both methods. There were seven of 35 episodes that did not terminate with rapid ventricular pacing (20%), and six of 35 that did not terminate with transvenous cardioversion (17%). Three episodes did not terminate with either, so that unsuccessful termination often demonstrated discordance between the two methods (figure 2).

Influence of antiarrhythmic therapy and ventricular tachycardia characteristics on the efficacy of both techniques for termination of ventricular tachycardia. The effects of specific factors such as antiarrhythmic therapy and characteristics of the tachycardia on the comparative efficacy of either technique for termination of ventricular tachycardia are examined in table 4. Efficacy of either technique was not affected by the presence or absence of antiarrhythmic therapy or specific characteristics of the arrhythmia, except in the case of transvenous cardioversion, which was more effective in ventricular tachycardia with longer cycle lengths (p < .05). Failure of either technique also could not be correlated with any of these factors.

Mechanism of termination of ventricular tachycardia with transvenous cardioversion and rapid ventricular pacing. Immediate termination of ventricular tachycardia was the most common mechanism of termination with both methods (transvenous cardioversion 88%, rapid

TABLE 2
Electrocardiographic, electrophysiologic, and ventricular tachycardia (VT) characteristics in patients in groups A and B before application of transvenous cardioversion or rapid ventricular pacing

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 7)</th>
<th>Group B (n = 8)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG and EP parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean QRS duration (msec)</td>
<td>118 ± 31</td>
<td>133 ± 44</td>
<td>NS</td>
</tr>
<tr>
<td>Mean corrected QT interval (msec)</td>
<td>469 ± 53</td>
<td>472 ± 71</td>
<td>NS</td>
</tr>
<tr>
<td>Mean RV ERP (msec)</td>
<td>273 ± 29</td>
<td>268 ± 24</td>
<td>NS</td>
</tr>
<tr>
<td>VT characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. VT episodes</td>
<td>17</td>
<td>18</td>
<td>NS</td>
</tr>
<tr>
<td>Control EPS</td>
<td>3</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>Drug EPS</td>
<td>14</td>
<td>14</td>
<td>NS</td>
</tr>
<tr>
<td>Mean cycle length (msec)</td>
<td>388 ± 73</td>
<td>403 ± 101</td>
<td>NS</td>
</tr>
<tr>
<td>Morphology (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBBB</td>
<td>9</td>
<td>8</td>
<td>NS</td>
</tr>
<tr>
<td>LBBB</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Indeterminate</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

ECG = electrocardiographic; EP = electrophysiologic; RV ERP = right ventricular effective refractory period; other abbreviations are as in table 1.
ventricular pacing 96%). Change in morphology of ventricular tachycardia before termination was observed during two episodes after transvenous cardioversion (6%) and in one episode after rapid ventricular pacing (4%). Acceleration of ventricular tachycardia before termination was observed only during two episodes (6%) in which transvenous cardioversion was attempted.

Safety of transvenous cardioversion and rapid ventricular pacing

Sustained acceleration of ventricular tachycardia or ventricular fibrillation (figure 3). Sustained acceleration of induced ventricular tachycardia was observed during four episodes in three patients who underwent transvenous cardioversion (incidence per shock 7%, incidence per episode 11%), and during two episodes in two patients who underwent rapid ventricular pacing (incidence per burst 2%, incidence per episode 6%). There was no overlap between patients experiencing acceleration of tachycardia with both methods. The differences between the two methods were not statistically significant (p > .2). Induction of ventricular fibrillation was not encountered with either method. However, a substantial proportion of patients in whom termination failed with both techniques developed accelerated ventricular tachycardia.

Supraventricular tachyarrhythmias. Transient supraventricular tachycardias were observed after termination of ventricular tachycardia by both methods. Termination with transvenous cardioversion was followed by atrial fibrillation (five episodes), atrial flutter (two episodes), and sinus tachycardia (one episode), for an
Overall incidence of tachyarrhythmia of 23%. These arrhythmias were usually nonsustained, although sustained atrial flutter/fibrillation was observed in two episodes (6%) in two patients. One episode terminated spontaneously and the other was terminated by infusion of procainamide. Sustained sinus tachycardia was observed after termination of ventricular tachycardia with rapid ventricular pacing during one episode (incidence 3%).

**Electrode catheter dislodgement.** Catheter dislodgement was not observed with either technique in this study.

**Patient tolerance.** Subjective patient discomfort during episodes of ventricular tachycardia treated with transvenous cardioversion was reported to be severe by seven (20%), moderate by 13 (37%), mild by 11 (31%), and absent by four patients (12%). Rapid ventricular pacing was painless in all instances. This difference was highly significant (p < .001).

### Discussion

**Efficacy.** The efficacy of programmed ventricular extrastimuli and rapid ventricular pacing for termination of sustained ventricular tachycardia has been previously documented.² 7-10 Long-term therapy by this approach with implantable devices has been reported.¹¹-¹⁶ Zipes et al.⁴ documented successful termination of ventricular tachycardia using intracavitary countershocks delivered with a transvenous electrode catheter. Recently the same investigators reported their early experience with an implantable low-energy cardioversion device for termination of sustained tachycardia.¹⁷

The efficacy rates of pacing techniques for termination of ventricular tachycardia have varied depending on the mode used. Uncontrolled studies have suggested that bursts of rapid ventricular pacing have superior efficacy when compared with programmed ventricular extrastimuli.² ¹⁸ Whereas overall efficacy rates for one or two extrastimuli vary from 42% to 50%, these have varied from 60% to 89% for bursts of rapid ventricular pacing.² ¹⁸ The major factor determining efficacy was the cycle length of the tachycardia and antiarrhythmic drug therapy increased efficacy only if it prolonged the cycle length. The efficacy of different transvenous cardioversion protocols for termination of ventricular tachycardia has been recently examined in our laboratory with the use of a prospective randomized study design.⁵ The overall efficacy of this technique in unselected patients was 62%. Factors influencing efficacy included (1) cycle length of ventricular tachycardia, (2) energy of delivered shock, (3) tilt of energy waveform, (4) time to initial cardioversion, and (5) QRS duration in sinus rhythm.⁵ ¹⁹

The present study compared the efficacy of these two methods with the use of a prospective randomized crossover study design. In comparing the efficacy of the two methods it was necessary to select an optimal protocol for each method. We have previously demonstrated that 83% of all successful transvenous cardioversion of ventricular tachycardia is achieved at energies up to 2.0 J.⁵ Since patient tolerance rapidly

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**FIGURE 2.** Concordance and discordance of results with transvenous cardioversion and rapid ventricular pacing in successful and unsuccessful attempts at termination of ventricular tachycardia.
TABLE 4
Comparative efficacy of transvenous cardioversion (TC) and rapid ventricular pacing (RVP) as related to specific factors

<table>
<thead>
<tr>
<th>Drug therapy</th>
<th>Successful termination of VT</th>
<th>Unsuccessful termination of VT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TC</td>
<td>RVP</td>
</tr>
<tr>
<td>Control EPS (%)</td>
<td>78</td>
<td>89</td>
</tr>
<tr>
<td>Drug EPS (%)</td>
<td>85</td>
<td>77</td>
</tr>
</tbody>
</table>

VT characteristics

<table>
<thead>
<tr>
<th>VT morphology (n)</th>
<th>Mean VT cycle length (msec)</th>
<th>VT morphology (n)</th>
<th>Mean VT cycle length (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBBB</td>
<td>408 ± 90</td>
<td>390 ± 72</td>
<td>NS</td>
</tr>
<tr>
<td>LBBB</td>
<td>14</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

VT = ventricular tachycardia; other abbreviations are as in tables 1 and 2.

declines at energies beyond this, an upper limit of 2.7 J was selected in this study. Retrospective analysis by Fisher et al. of bursts of rapid ventricular pacing resulting in successful termination of ventricular tachycardia indicated that rates between 70% to 90% of cycle length of the tachycardia have the highest success rates. At extremely short pacing cycle lengths one-to-one ventricular capture cannot be achieved. In addition, up to 5 to 10 captured paced beats are usually needed. Therefore pacing rates of 90%, 75%, and 65% of cycle length were selected with pacing trains of 10 and 15 beats to allow a sufficient number of pacing captures during asynchronous pacing.

Our observations indicate that these two methods of electrical therapy have comparable efficacy for termination of sustained ventricular tachycardia when the protocols used in this study are applied. The mechanisms of successful termination of ventricular tachycardia by both techniques appear to be similar. Prior studies in which endocardial catheter mapping was applied during transvenous cardioversion suggest that it can either interrupt or reset and destabilize the ventricular tachycardia circuit. Entrainment and interruption of ventricular tachycardia with rapid ventricular pacing has also been demonstrated. Pacing termination of ventricular tachycardia can be explained either by penetration of the tachycardia circuit by the impulse with both antegrade and retrograde block or by development of instability due to resetting of the circuit and appearance of new areas of conduction block. Similar mechanisms could explain the efficacy of transvenous cardioversion and rapid ventricular pacing in termination of ventricular tachycardia. Systematic cardiac mapping studies will be needed to further clarify these mechanisms.

Safety. Earlier studies have estimated the incidence of acceleration of ventricular tachycardia with rapid ventricular pacing to vary from 4% to 18%. However, a preselected systematic protocol was not used in these studies. On the basis of previous data, we used a controlled preselected incremental pacing protocol and noted a low incidence (2%) of this complication, the mechanisms of which include reinduction of the tachycardia after termination by late pacing-captured beats. These tachycardias can use alternative reentrant pathways as a result of modification of electrophysiologic parameters in the conducting tissues in the circuit. Further modification of our protocol could conceivably minimize or eliminate this complication. Acceleration of tachycardia was also observed during transvenous cardioversion. While the mechanisms of this

FIGURE 3. Top, Incidence of ventricular tachycardia acceleration during all episodes of tachycardia during transvenous cardioversion and rapid ventricular pacing. Bottom, Incidence of ventricular tachycardia acceleration during transvenous cardioversion and rapid ventricular pacing in unsuccessful attempts at termination of tachycardia.
phenomenon have not been systematically examined, they could be similar to those postulated for rapid pacing. We have previously reported an incidence of 8% per shock in unselected patients. However, drug therapy may reduce the frequency of this complication. In this study the incidence of acceleration in drug-treated patients was lower (7%).

Transient arrhythmias after termination of ventricular tachycardia were more frequent after transvenous cardioversion than after rapid ventricular pacing. While these were usually nonsustained, we have observed sustained supraventricular arrhythmias after transvenous cardioversion in this and prior studies. These may have considerable importance with reference to reestablishing hemodynamic stability after termination of ventricular tachycardia as well as for sensing algorithms of implantable cardioversion devices. Also, patient tolerance of rapid ventricular pacing was clearly superior to transvenous cardioversion. Stability of the electrode catheter was demonstrated with both methods in this report.

Limitations of current study. Reproducibility of our results with regard to the efficacy and safety of the two methods used has not been established by our observations. This is an important issue since repeated demonstration of the efficacy and safety of the electrical therapy mode is necessary before implantation of permanent devices. Furthermore, differences between the cycle lengths of induced ventricular tachycardia and spontaneous clinical ventricular tachycardia remain a major problem in attempting to predict results of long-term use of these therapeutic devices. The time interval between the initiation of ventricular tachycardia and the application of therapy also remains an important issue. We have previously reported that successful transvenous cardioversion of ventricular tachycardia is associated with a shorter time interval between onset of tachycardia and delivery of shock. A systematic analysis of this issue for both transvenous cardioversion and rapid ventricular pacing was not performed as a result of the constraints imposed by the need to deliver multiple therapies during the study. A systematic controlled study of this issue is clearly warranted.

Potential roles of rapid ventricular pacing and transvenous cardioversion in electrical therapy of ventricular tachycardia. Available information suggests that both of the techniques we studied have limited efficacy in unselected patients with ventricular tachycardia, but that this can be increased by careful patient selection. The higher degree of efficacy observed in this study as compared with prior reports could be due to the longer cycle lengths of ventricular tachycardia we observed in drug-treated patients. Both methods have comparable and usually concordant efficacy, indicating that in many cases they are competitive, but rapid ventricular pacing has significant advantages with respect to patient tolerance and postcardioversion arrhythmias. With the delineation of a preselected pacing protocol some of the cumbersome aspects of selection of rapid ventricular pacing protocols can be eliminated. Both methods carry a small but definite hazard of acceleration of ventricular tachycardia and should only be used, both in short- and long-term therapy, when high-energy cardioversion/defibrillation capability is available.

We can visualize the use of pacing methods as a complement to, and preceding the application of, low- or high-energy countershock for termination of ventricular tachycardia. When carefully and systematically applied, this would, in our opinion, substantially reduce the number of patients exposed to the unpleasant and traumatizing experience of high-energy electrical countershock and would be ideal for temporary use, for example in an intensive care unit. For long-term treatment of ventricular tachycardia with implanted electrical devices rapid ventricular pacing techniques may offer superior patient tolerance and easier differentiation of postcardioversion rhythms with currently available sensing algorithms. They should, in our opinion, be considered as the first line of electrical therapy by an implanted unit before proceeding to cardioversion techniques. However, the discordance between transvenous cardioversion and rapid ventricular pacing with respect to the episodes of ventricular tachycardia failing to terminate with either technique suggests that transvenous cardioversion may play a complementary role in treatment of some patients. This may particularly apply to patients with tachycardias of longer cycle lengths. In such a case the optimum electrical therapy may be pacing with low-energy cardioversion as sequential therapy and with high-energy cardioversion on standby.

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