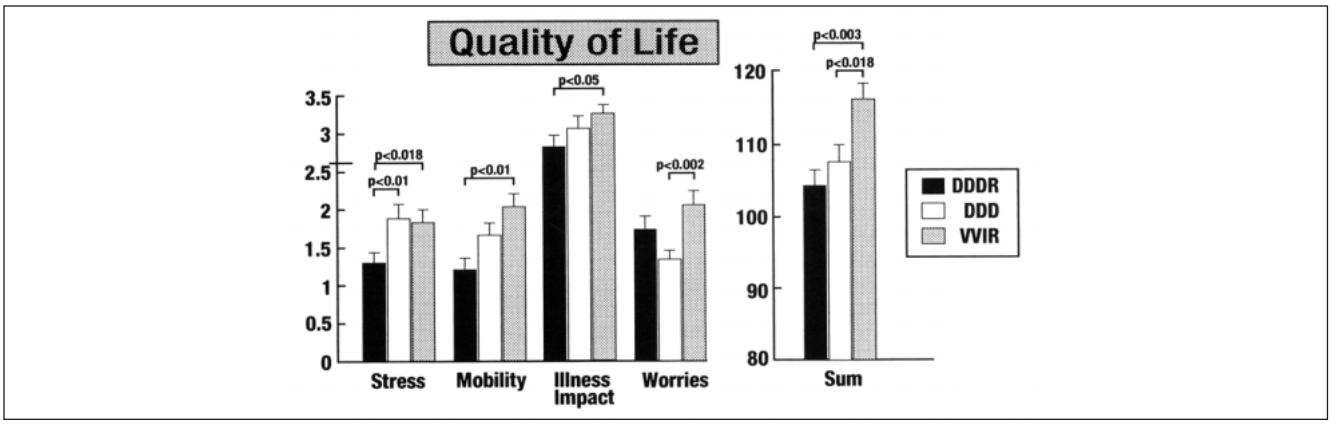
Goals of Pacing Therapy



The goals of pacing therapy are to improve long-term cardiac and hemodynamic performance and enhance the patient's quality of life.

Quality of life is improved when pacing therapy provides as many of the physiological characteristics of normal cardiac function as possible, given the patient's disease state. Optimally, pacing results in cardiac output sufficient to meet metabolic demand during rest and activity and, as much as possible, preservation of heart rate and stroke volume reserves. This is achieved when pacing provides:

- A *heart rate response* appropriate for the patient's level of activity at any given moment,
- *AV synchrony* - that is, a contraction sequence that enables the atria and ventricles to work together to optimize ventricular filling, and
- A *ventricular activation pattern* that allows the ventricles to contract on their own as much as possible. Because a paced ventricular beat starts at the myocardial cells at the lead tip, it does not travel the normal conduction path. Evidence has shown that this alters ventricular systolic and diastolic function to some extent. Intrinsic conduction, on the other hand, preserves normal ventricular activation and may improve left ventricular function and prevent the onset of tachyarrhythmias.

Various modes of pacing have different effects on cardiac hemodynamics. Also, the electrical and hemodynamic status of an individual may change over time. To select a pacing mode that provides adequate hemodynamic performance over the long term, it is important to consider not only the patient's current electrophysiological status, but also how that status may change over time.

Notes

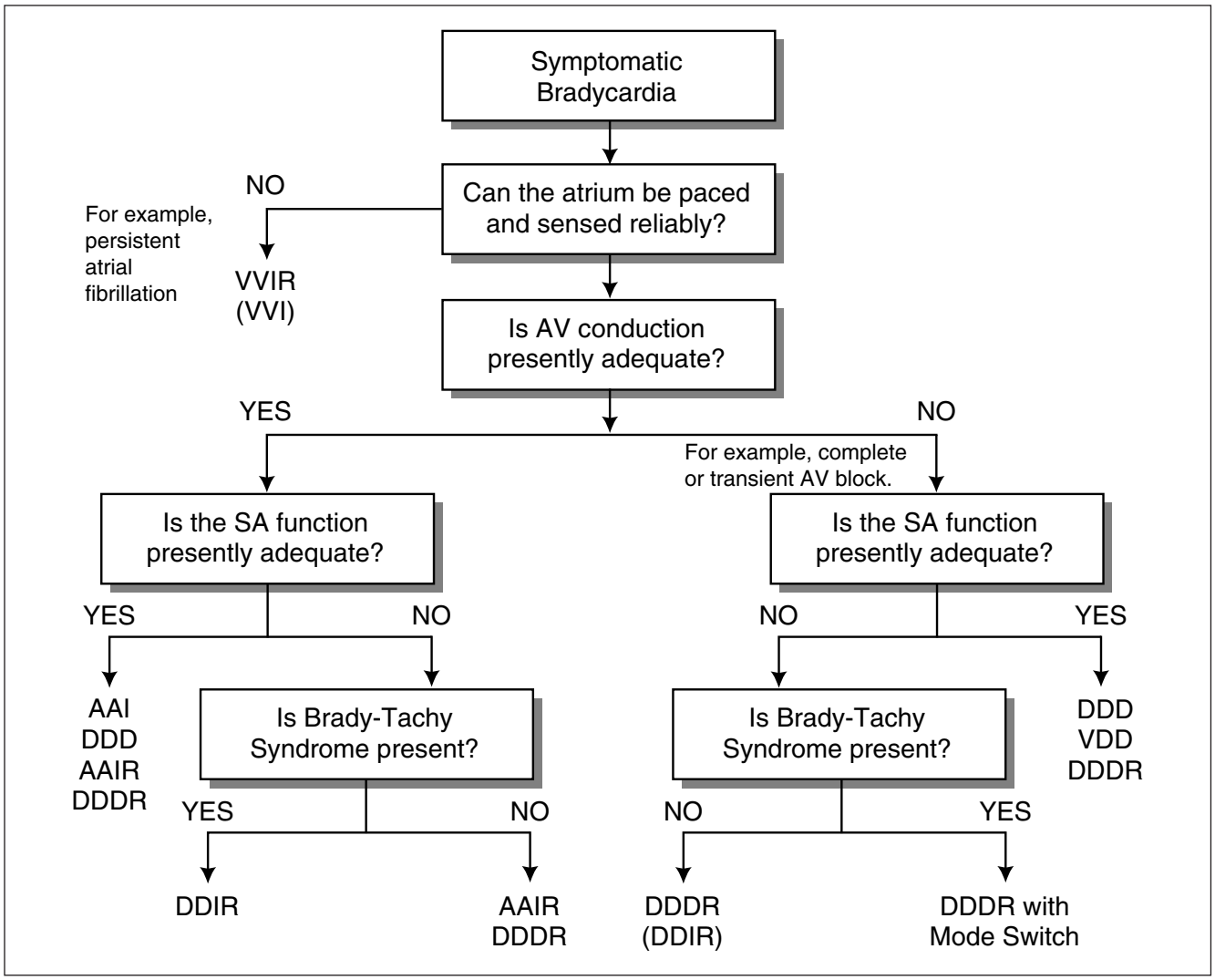
Optimal pacing therapy provides AV synchrony, an adequate heart rate response to patient activity, and normal ventricular activation whenever possible.

True or False:

When selecting a pacing mode, it is important to consider the patient's present and future electrophysiological status.

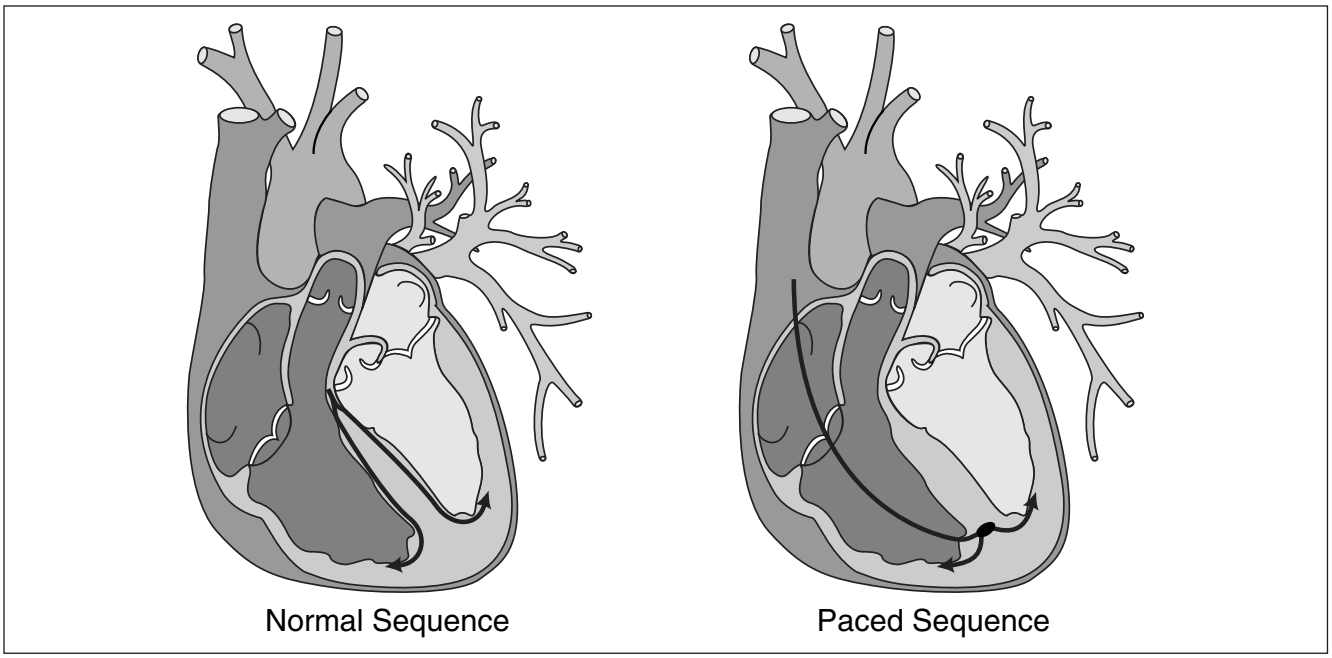
Answer: True

Mode Selection Process for Patient with Symptomatic Bradycardia



Note: Modes in parenthesis are considered less desirable because they provide less than optimal pacing therapy.

Achieving AV Synchrony



Atrial-based single or dual chamber pacing may be used to achieve AV synchrony.

Atrial-based pacing refers to modes that pace and sense the atrium (AAI/R, DDD/R). ***AAI/R*** *requires* intact AV conduction (which may be tested with rapid atrial pacing or carotid sinus massage).* When intrinsic depolarization occurs in AAI/R modes, the intrinsic P-wave is conducted to the ventricles. When atrial pacing occurs, the paced P-wave is conducted to the ventricles. In either event, AV synchrony and the normal ventricular activation sequence are preserved.

DDD/R is appropriate for patients with AV block and patients who are expected to develop AV block. Appropriately programmed sensed and paced AV intervals (SAV and PAV) provide sufficient time for adequate left ventricular filling and ensure AV synchrony. DDD/R also permits conduction of the P-wave when intrinsic AV conduction is intact, provided AV interval is appropriate, and therefore promotes normal ventricular activation.

* It is important to test AV conduction before programming and to monitor it at follow-up. Single chamber atrial-based pacing is inappropriate if there is any uncertainty about the reliability of AV conduction

Notes

Atrial-based pacing preserves AV synchrony and supports normal ventricular activation.

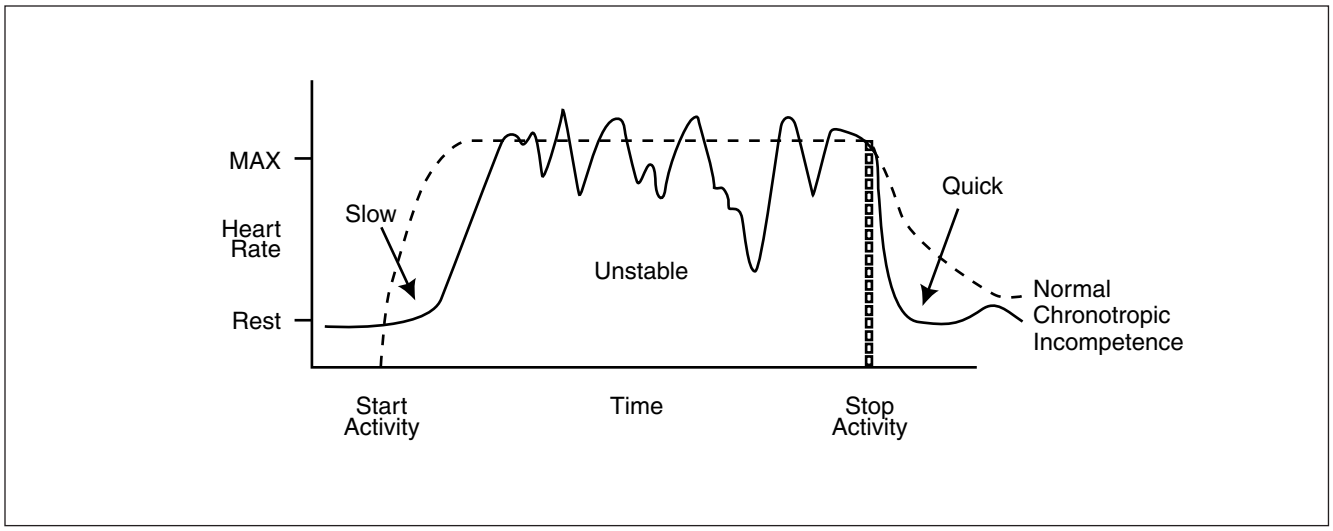
Questions:

In (AAI/R, DDD/R) modes, intrinsic AV synchrony is preserved.

In (AAI/R, DDD/R) modes, AV synchrony is achieved with appropriate programming of AV intervals.

Answer: AAI/R / DDD/R

Providing Rate Response



Rate responsive modes are appropriate when the heart is or is expected to become chronotropically incompetent.

Chronotropic incompetence is an inadequate or inappropriate heart rate response to exercise or other metabolic demand. Specifically, it is often defined as the failure to achieve 75% of one's age-predicted maximum heart rate (220 minus age) at peak exercise.

If the atrial rhythm is always useful, non-rate responsive modes (AAI, DDD) are appropriate, but if the atrial rhythm shows any signs of abnormality (occasional atrial tachycardias, retrograde conduction, possible loss of atrial sensing), rate responsive pacing (AAIR, DDDR, VVIR) is more suitable. Recall that adequate rate response (with or without AV synchrony) is the most important mechanism for increasing cardiac output with exercise (see Module 1).

There are several arguments in favor of using rate responsive modes more widely. One is significant patient benefit, including increased exercise capacity at any level of physical fitness, improved ventilatory response, lower resting rates when appropriate, and an improved perception of well-being by the patient. Another is that the prevalence of chronotropic incompetence increases with time. Studies show an incidence > 70% in patients paced longer than four years.

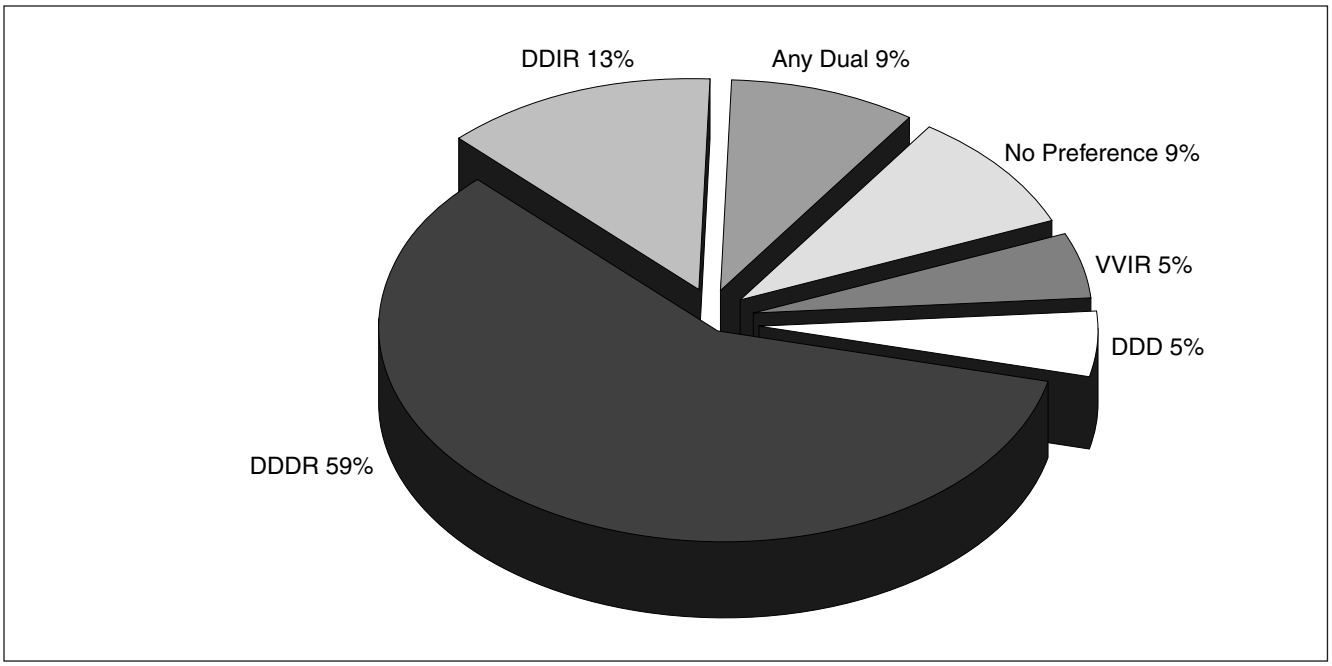
Notes

True or False:

Rate responsive pacing is appropriate for patients whose sinus node may become chronotropically incompetent. _____

Answer: True

VVI/R Pacing



VVI/R pacing is clearly indicated only for patients with chronic atrial fibrillation associated with symptomatic bradycardia.

In the presence of chronic atrial fibrillation or inexcitable tissue, the goal of AV synchrony cannot be met because the atria have no useful rhythm. VVI/R pacing is therefore the only option. VVIR is more desirable than VVI because patients who engage in even a moderate amount of activity benefit from rate response, especially when there is no chance for AV synchrony.

Ventricular pacing is associated with adverse effects such as atrial fibrillation, stroke, congestive heart failure, and *pacemaker syndrome* (signs and symptoms of poor hemodynamics that result primarily from the loss of AV synchrony). These adverse effects exist in both VVI and VVIR patients, both at rest and during exercise. Therefore, even though ventricular pacing improves the quality of life in patients with an unstable atrium, it does not provide optimal pacing therapy.

Notes

Questions:

VVI/R pacing (can, cannot) provide optimal pacing therapy and is indicated only in the presence of (chronic atrial fibrillation, AV block) associated with symptomatic bradycardia.

Answer: cannot / chronic atrial fibrillation

Benefits of Atrial-Based Pacing

Study	Results
Rosenquist 1988	Less atrial fibrillation (AF), less CHF, improved survival after 4 years compared to VVI
Santini 1990	Less AF, improved survival after 5 years average
Stagl 1990	Less AF, improved survival after 5 years compared to VVI Suppression of atrial dysrhythmias
Zanini	Improved morbidity (less AF, CHF, embolic events) after 3 plus years, compared to VVI
Higano *et al.* 1990	Improved cardiac index during low level exercise (where most patient activity occurs)
Gallik *et al.* 1994	Increase in LV filling
Santini *et al.* 1991	30% increase in resting cardiac output
Rosenqvist *et al.* 1991	Decrease in pulmonary wedge pressure Icrease in resting cardiac output
Sulke *et al.* 1992	Increase in resting cardiac output, especially in patients with poor LV function Decreased incidence of mitral and tricuspid valve regurgitation

With and without rate response, atrial-based pacing provides significant hemodynamic improvement and patient benefit.

Studies have shown that the atrial-based AAI/R and DDD/R pacing offers these benefits over VVI/R pacing:

- Lower incidence of new-onset atrial fibrillation and thus a lower risk of thromboembolism and stroke,
- Preservation of myocardial contractility and thus a reduction in congestive heart failure and mortality,
- Decreased cardiothoracic ratio and left atrial size,
- Possible prevention of paroxysmal atrial fibrillation with brady-tachy syndrome, and
- Higher five-year survival rates.

Note: Studies show that about 90% of paced patients have a preserved sinus rhythm, which suggests expanded use of atrial-based pacing.

Notes

Compared with ventricular pacing, atrial-based pacing offers significant benefits in clinical outcome and patient survival.

True or False:

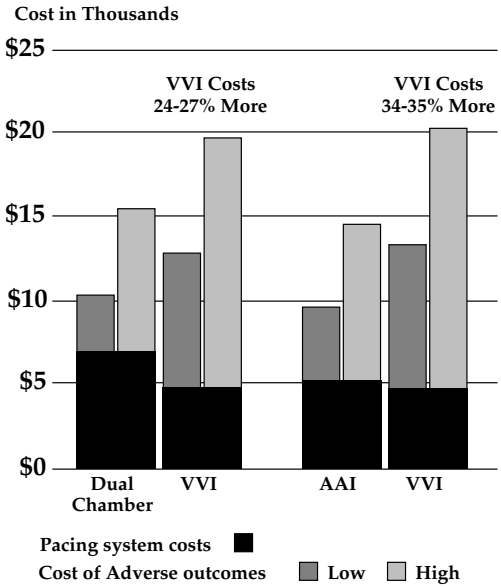
Atrial-based pacing may prevent atrial fibrillation and congestive heart failure. _____

Answer: True

The Role of Cost in Mode Selection

Adverse Outcomes	Increased Cost of Treatment Associated with VVI Pacing
Atrial Fibrillation	+279% compared to DDD patients +343% compared to AAI patients
Congestive Heart Failure	+62% compared to DDD patients +228% compared to AAI patients
Stroke	+241% compared to DDD patients +327% compared to AAI patients
Pacemaker Syndrome	+147% compared to DDD patients +179% compared to AAI patients
Cost of Adverse Outcomes	**+149-154% compared to DDD patients** **+226-285% compared to AAI patients**

Overall Cost of Pacing
A Comparison of Pacing Modes



An important consideration in mode selection is overall pacing cost, which includes the cost of initial implant and the cost of long-term patient care.

The table above shows the higher cost of treatment associated with ventricular pacing, and the graph compares overall costs of dual chamber and single chamber atrial and ventricular pacing. These indicate that:

- The cost of treating adverse outcomes in VVI/R paced patients is about 150% higher than in DDD/R paced patients and 260% higher than in AAI/R paced patients.
- After factoring in the higher cost of initial device implant, the overall cost of VVI/R pacing is 24% to 27% higher than DDD/R pacing and 34% to 35% higher than AAI/R pacing.

Notes

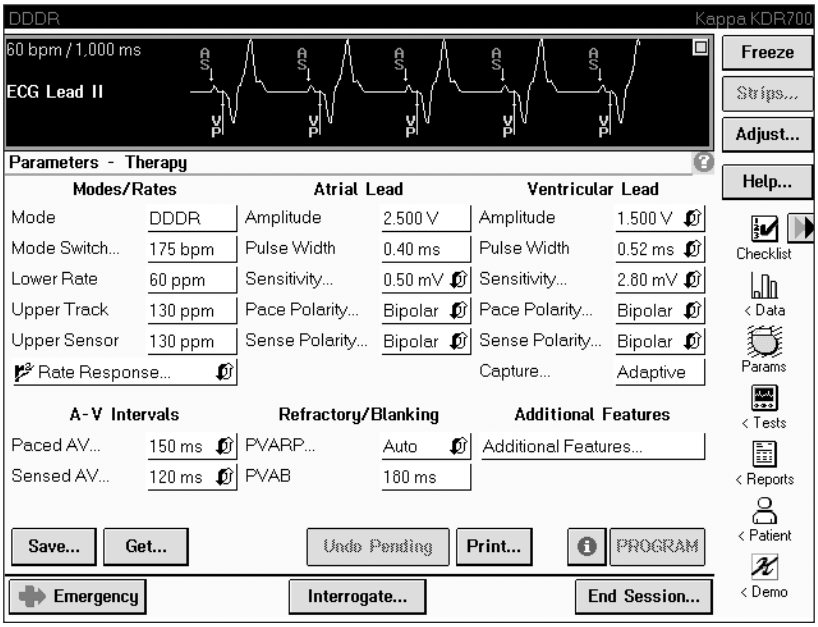
Evidence indicates that when treatment costs associated with adverse health outcomes are considered, atrial-based pacing is less costly than ventricular pacing.

True or False:

In the long run, it may be more cost-effective to implant a dual chamber pacemaker, despite its higher initial cost. _____

Answer: True

The Importance of Therapeutic Flexibility



Therapeutic flexibility is desirable because the electrophysiological and hemodynamic status varies between patients and may change in a patient over time.

DDDR pacemakers have the therapeutic flexibility to meet the needs of patients who may develop AV block, tachyarrhythmia, or other conditions that may require a change in the pacing prescription. DDDR pacemakers provide:

- Separately programmable paced and sensed AV intervals, which allow appropriate timing of atrial systole and ventricular diastole and support ventricular activation whenever possible.
- Rate-adaptive AV intervals that shorten and lengthen with changes in the heart rate.
- Automatic mode switching, which suspends atrial tracking upon detection of fast atrial rates and thus protects patients who develop paroxysmal atrial fibrillation.
- Cardiac event counters, which may be used to assess rate response and fine-tune programming.

Therapeutic flexibility ensures optimal pacing in patients whose condition may change within several years of implant.

Notes