Coronary pacing during percutaneous transluminal coronary angioplasty

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ABSTRACT To avoid venous puncture, a new concept for standby cardiac pacing during percutaneous transluminal coronary angioplasty (PTCA) and diagnostic cardiac catheterization was developed. It uses an arterial guidewire as a unipolar pacing electrode with the second electrode attached to the skin. The system was tested in 25 coronary arteries of 22 patients undergoing PTCA and in the left ventricles of 10 patients undergoing diagnostic cardiac catheterization. Coronary pacing via the guidewire used for directing the balloon catheter was possible in all patients and in 24 of the 25 coronary arteries attempted. Maximum duration of pacing was 8 min. Threshold currents ranged from 1 to 15 mA (mean 5.7). Left ventricular pacing via the same wires or standard wires used for introduction of diagnostic or guiding catheters was possible in all patients and was maintained for up to 10 min. Threshold currents ranged from 1 to 7 mA (mean 3.9). Neither method for pacing produced adverse effects during these short applications. The setup for coronary pacing also allowed recording of an intracoronary electrocardiogram during PTCA. The presented system provides backup for the rare event of sustained bradycardia during PTCA or diagnostic cardiac catheterization. If applied cautiously, it may safely and reliably replace the standby of a conventional transvenous pacing catheter.


SINCE the first description of percutaneous transluminal coronary angioplasty (PTCA) in men,1 it has been recommended to insert a temporary venous pacing catheter prophylactically for the event of bradycardia or asystole during the procedure. This preventive act prolongs the procedure, increases cost, and is associated with morbidity.2–4 Wires used for the introduction of angiographic catheters or for guidance of PTCA catheters (coronary guidewires) can be used as unipolar pacing electrodes. Their electrical resistance is less than 50 Ω and therefore negligible. Insulation of the wire within the body is provided by the catheter.

Based on preliminary animal experiments,5 this new concept for standby pacing during PTCA or routine cardiac catheterization was tested in patients.

Methods

Technique. For coronary pacing, the tip of the guidewire (Schneider Medintag, diameter 0.012 or 0.014 inch; ACS, diameter 0.018 inch) was advanced in the affected coronary artery until it made contact with the wall either in a distal part of the main vessel itself or in a small side branch. Outside of the body, the end of the wire was connected to the cathode of a commercial, battery operated, external pulse generator (Medtronic 5375; constant current, maximum output 12 V, pulse width 1.7 msec). A special device was developed to allow for easy connection without loss of torquing capability during directional advancement of the wire. The anode of the pulse generator was connected to a skin electrode on the left arm with a surface of about 20 cm². Pacing was begun at a rate of about 100 impulses per minute at the maximum output of the generator (dial set at 20 mA). The output current was then decreased to determine the pacing threshold current and pacing was continued for approximately 1 min at an output of 3 mA above threshold current. If threshold current exceeded the maximum output of the generator the wire tip was repositioned. The position of the wire tip was filmed as reference for inspection of the pacing site on the final coronary angiogram. After removal, the guidewire tip was visually checked for adherence of clots or debris.

An intracoronary electrocardiogram was recorded in selected cases during balloon dilatation. For this purpose the guidewire was connected to the chest lead terminal of a multichannel electrocardiograph.

Left ventricular pacing was performed with coronary guidewires or with 0.035 inch J-tip Cordis wires (for introduction of diagnostic catheters) or 0.063 inch J-tip Schneider wires (for introduction of PTCA guiding catheters) used as unipolar electrodes. Teflon coating was mechanically removed from the tips of wires before use. The wires were introduced through diagnostic catheters (pigtail or multipurpose shape) or through PTCA guiding catheters.

All patients received 15 mg of diazepam orally 1 hr before the procedure. At the beginning of the intervention they underwent heparinization intravenously; PTCA patients received 10,000 U

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and patients with left ventricular pacing received 2500 U. PTCA patients received nifedipine and isosorbide dinitrate (0.1 to 0.2 mg each) delivered into the affected coronary artery a few minutes before the pacing.

Patients. In 22 patients undergoing PTCA at our institution, the described method for coronary pacing was tested in 25 different coronary arteries. Only one patient was a woman. Their mean age was 55 years with a range from 38 to 65.

Left ventricular pacing was tested in 10 patients undergoing diagnostic cardiac catheterization. Three patients were women, with a mean age of 53 years (range 40 to 64). In six of them left ventricular pacing was done for a diagnostic purpose. Starting from 100 beats/min, the pacing rate was increased at 2 min intervals by 20 beats/min until angina pectoris developed or to a maximum of 180 beats/min. Left ventriculograms were obtained before and after the pacing episode and compared for provokable hypokinesia.

Results

Coronary pacing with complete capture was possible in all 22 patients. In three patients with double-vessel PTCA, pacing was attempted in both vessels. In one patient pacing failed in the circumflex coronary artery at maximum output despite four repositionings of the wire tip. The area of the pacing attempts had been previously infarcted. In the diagonal coronary artery of the same patient capture was achieved at a threshold current of 1 mA. Pacing with the described generator was thus possible in 24 of 25 coronary arteries attempted. Figure 1 documents an example of coronary pacing.

In one patient pacing had to be used therapeutically. He developed a junctional rhythm with severe bradycardia during the initial phase of PTCA. Coronary pacing was maintained over 8 min while PTCA was successfully completed. In another patient pacing was used diagnostically to assess the significance of a mild stenosis in the left anterior descending coronary artery. The patient had a permanent pacemaker implanted. The danger of dislodging the permanent pacing lead by introducing a temporary one was obviated by the coronary pacing method. The rate was increased by about 20 beats/min in 30 sec intervals to a maximum of 182 beats/min. No translesional gradient could be provoked (figure 2).

The sites of coronary pacing and the corresponding threshold currents are listed in table 1. Mean threshold current for pacing was 5.7 mA (range 1 to 15 mA). Pacing was perceived by some patients as a repetitive stinging sensation at the skin electrode. But even at maximum output of the generator (12 V) this was described as only a mild discomfort.

No other effects attributable to the pacing occurred. The pacing site invariably appeared normal on the con-

FIGURE 1. Coronary pacing in a branch of the left circumflex coronary artery of a 49-year-old male patient. The inset shows the site of pacing (arrow) in a right anterior oblique projection.
FIGURE 2. Diagnostic coronary pacing in a septal branch of the left anterior descending coronary artery of a 59-year-old male patient to assess the significance of a proximal stenosis. No significant gradient between aortic pressure and coronary pressure distal to the stenosis was present at any heart rate tested. The inset shows the site of the pacing (arrow), the site of the stenosis (double arrow), and the site of the coronary pressure measurement (triple arrow) in a right anterior oblique projection. The permanent pacing lead is marked by a quadruple arrow.

FIGURE 3. Intracoronary electrocardiogram of a 52-year-old male patient before, during, and after balloon dilatation of the left anterior descending coronary artery. The marked ischemic changes were accompanied by typical chest pain. The inset shows the site where the electrocardiogram was taken (arrow) in a right anterior oblique projection.
trol angiogram. In one patient some fibrin deposits were seen adherent to the tip of the removed coronary guidewire. The wire tip had been left for about 15 min in wedging position in a small septal branch of the posterior descending coronary artery. The particular branch remained patent.

Figure 3 shows an example of an intracoronary electrocardiogram during different phases of the PTCA procedure.

The pertinent data of the patients with left ventricular pacing are listed in table 2. Mean pacing threshold current was 3.9 mA (range 1 to 7 mA).

**Discussion**

Sustained bradyarrhythmias during PTCA are rare. The reported 22 patients were selected for threshold current determinations at random from a consecutive group of 102 patients undergoing PTCA without the precaution of a venous pacing catheter. Pacing became clinically necessary in only one patient (1%). A multicenter report about complications of PTCA indicated a rate of 2% of significant bradyarrhythmias during PTCA. In the rare cases in which bradyarrhythmia occurs, it has to be remedied without delay. To introduce a venous pacing catheter at that moment may take too much time and may necessitate cardiac massage until pacing is available. Hence, the call for prophylactic insertion of a venous pacing system for PTCA seems justified unless an alternative standby pacing system is at hand. The described concept represents such a system, which proved reliable and well tolerated during brief application in a small series of patients. It allows initiation of pacing within less than a minute in any phase of PTCA or diagnostic cardiac catheterization. If bradycardia occurs while there is no wire in the coronary artery, a wire for left ventricular pacing can be quickly introduced into the left ventricle by crossing the aortic valve with the guiding catheter. Skin contact and connection between wire and pulse generator should be mounted prophylactically or at least kept ready. It has to be ascertained that the pacing wire is connected to the cathode of the pulse generator because pacing with the anode results in higher threshold currents. The shorter the segment of the wire that protrudes from the catheter inside the body, the better the insulation of the system. An uninsulated segment from the aortic cusp to a distal coronary artery or to the apex of the left ventricle proved acceptable. There was only one occurrence of a pacing threshold current exceeding the maximum output of the generator used, which was probably caused by previous infarction of the territory.

The described system was devised to replace conventional temporary pacing by venous route in some settings. If a prolonged episode of pacing is anticipated, coronary pacing cannot be used. Prolonged coro-

**TABLE 2**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Pacing threshold (mA)</th>
<th>Pacing duration (min)</th>
<th>Maximum pacing rate (beats/min)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
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<tr>
<td>2</td>
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LAD = left anterior descending coronary artery; LCx = left circumflex coronary artery; LDg = left diagonal coronary artery; RCA = right coronary artery.
nary pacing led to coronary thrombosis in pigs. If an unanticipated coronary pacing episode needs to be pursued for more than a few minutes, the introduction of a conventional venous bipolar pacing catheter is advisable. For extended diagnostic pacing episodes with the presented system only left ventricular pacing should be used. For brief diagnostic pacing, e.g., for transstenotic pressure gradient measurements of increasing heart rates, the intracoronary system can be used with due caution (figure 2). Maneuvers to position the coronary guidewire for optimal pacing contact require skill and experience germane to all intracoronary manipulations and should be performed by the senior member of the angioplasty team.

The availability of the intracoronary electrocardiogram (figure 3) to assess the susceptibility of a myocardial area to the transient ischemia caused by the PTCA balloon provides an additional advantage of the described technical setup.

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