CRITICAL REVIEW

Percutaneous Transfemoral Venous Cardiac Pacing
A Simple and Practical Method*

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For temporary transvenous cardiac pacing to be successful and practical (1) electrode placement must be accomplished precisely and expeditiously; (2) the inserted electrode should not move spontaneously from the chosen site of endocardial stimulation; (3) prevention of electrode displacement should not be accomplished at the cost of inconvenience to the patient; and (4) the site of venous entry for temporary pacing should not compromise plans for later permanent transvenous pacemaker implantation. Of the four available venous routes, brachial, jugular, subclavian and femoral, only the last meets all these requirements. A simple percutaneous transfemoral venous method of cardiac pacing is described, and personal experience with its use in 100 consecutive patients presented. The necessary equipment for the procedure is within the reach of any hospital. This technique is particularly valuable in management of patients with malfunctioning permanent pacemakers, acute myocardial infarction complicated by A-V block or ectopic tachyarrhythmias, recurrent Stokes-Adams attacks, and refractory ventricular tachycardia, where expediency in establishing a stable rhythm is of paramount importance.

It is generally agreed that the best method for cardiac pacing is transvenous. This is true not only for all instances of temporary pacing but also for most of permanent pacemakers. There are several venous routes for introduction of a transvenous pacing electrode, either through a cutdown or by a percutaneous technique. The purpose of this communication is to describe a simple percutaneous transfemoral venous method which has been much under-utilized as a diagnostic or a therapeutic approach.

MATERIALS AND METHODS

Patients

The indications for cardiac pacing in the 100 consecutive patients are listed in Table 1. The ages of the patients ranged from 38 to 86 with the majority in the seventh and eighth decades.

Method

The percutaneous transfemoral venous approach is a modification of the technique originally introduced by Solomon and Escher. Instead of threading the electrode through the needle, the former was introduced into the femoral vein by a modification of the Seldinger technique.

All the necessary components are preassembled on a sterile tray ready for use (Fig. 1). After sterile preparation and draping of the femoral triangle, the femoral vein, usually the right, is punctured percutaneously, one finger breadth below the inguinal ligament and just medial to the femoral artery which is identified as well as protected from accidental entry by the fingers of the other hand. The needle (A) is an 18-gauge thin-wall Riley needle connected to a 10 ml syringe filled with a 1 to 2 percent lidocaine (B). Once the needle tip is within the lumen of the femoral vein, the syringe is disconnected and replaced by a 0.035 inch guide wire with a flexible tip (C). After satisfactory insertion of the guide wire, the needle is removed and replaced by a short Teflon inner catheter* (D), which is threaded over the wire and through the skin until the proximal end of the guide wire barely

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Table 1.—Indications for Pacing

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complete Heart Block with</strong></td>
<td></td>
</tr>
<tr>
<td>Stokes-Adams syndrome</td>
<td>37</td>
</tr>
<tr>
<td>Chronic brain syndrome vs CVA</td>
<td>5</td>
</tr>
<tr>
<td>Intra-operative control of rhythm</td>
<td>4</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>2</td>
</tr>
<tr>
<td>Renal insufficiency with azotemia</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50</td>
</tr>
<tr>
<td><strong>Acute Myocardial Infarction with</strong></td>
<td></td>
</tr>
<tr>
<td>High grade heart block</td>
<td>21</td>
</tr>
<tr>
<td>Recurrent ventricular tachyarrhythmias</td>
<td>2</td>
</tr>
<tr>
<td>Marked sinus bradycardia</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25</td>
</tr>
<tr>
<td><strong>Failure of Permanent Pacemaker</strong></td>
<td></td>
</tr>
<tr>
<td>Bilateral Bundle Branch Block</td>
<td>10</td>
</tr>
<tr>
<td>Atrial Flutter (for rapid atrial stimulation)</td>
<td>5</td>
</tr>
<tr>
<td>Digitalis Toxicity</td>
<td>4</td>
</tr>
<tr>
<td>Refractory Ventricular Tachycardia</td>
<td>3</td>
</tr>
<tr>
<td>Alternating Atrial Tachy-Bradyarrhythmias</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25</td>
</tr>
</tbody>
</table>

Fluoroscopic control, into the inferior vena cava and finally the right atrium. Due to the fact that terminal portion of the catheter is performed into a U-shape, the catheter can be readily passed from the right atrium into the apex of the right ventricle without any need of manipulation on the part of the operator. With this sharp curve at the tip it is extremely unlikely for the catheter to inadvertently enter the coronary sinus, thus obviating the dilemma of differentiating between coronary sinus pacing and catheter perforation of the ventricular septum. The entry of the catheter into the right ventricle is usually heralded by a few extrasystoles and confirmed by recording a typical unipolar intracavitary right ventricular electrogram from either electrode of the bipolar catheter through the surgical connecting cable (G). By means of the same connecting cable the pacing catheter is then connected to an external demand pulse generator (H) for determination of stimulation threshold. If demand pacing is not achieved at 1.3 milliamperes or below, even though the anatomical location appears suitable, the electrode should be repositioned. The extracorporeal portion of the electrode-catheter with its partially withdrawn outer dilating sheath is then securely taped along the inguinal ligament and a sterile dressing applied. The purpose of leaving the outer Teflon sheath in situ just outside the puncture site under the sterile dressing is that when reintroduced into the femoral vein it can provide a sterile conduit for later adjustment, manipulation or even replacement of the indwelling electrode-catheter without the risk of contamination. No anticoagulant or antibiotic, either topical or systemic, is used.

**RESULTS**

**Duration of Pacing**

The duration of transfemoral venous cardiac pacing...
pacing varied between two hours and 310 days, the average being 12 days.

Modes of Pacing

In the first 50 patients all pacing was in the asynchronous or "fixed-rate" mode. Demand pacemakers were used in the last 50 patients except when the purpose of pacing was rapid atrial pacing in treatment of atrial flutter or overdriving for treatment of ventricular tachycardia and of alternating atrial tachy- and bradyarrhythmias.

Outcome of Patients

All patients with complete heart block and Stokes-Adams syndrome had temporary transfemoral venous pacing for various lengths of time followed by implantation, repair or replacement of permanent transvenous units via either the jugular or cephalic vein.

Rapid atrial stimulation was successful in converting atrial flutter to regular sinus rhythm in all of the five patients so treated (Fig 2).

One of three patients with digitals toxicity and high grade heart block died one day later of intractable congestive heart failure in spite of effective control of the ventricular rhythm and rate. The other two digitoxic patients had atrial fibrillation and almost complete heart block; both responded well to demand pacing which was discontinued after 48 hours when satisfactory ventricular response returned.

All patients with acute myocardial infarction and high grade heart block were paced transfemorally. Fifteen had inferior wall infarcts; in 14 of them the A-V block was Wenckebach in type and transient in nature. One patient with inferior myocardial infarct and complete heart block died of cardiogenic shock on the tenth day in spite of effective control of the ventricular rate. Six patients had anterior myocardial infarcts, four of whom developed Mobitz type II block, and two, complete heart block. All six died either in cardiogenic shock or of congestive heart failure, in spite of satisfactory control of the ventricular rate. Two patients with acute myocardial infarct and marked sinus bradycardia survived.

One patient with alternating atrial tachy- and bradyarrhythmia had temporary pacing for two weeks followed by permanent implantation.

Of four patients with refractory and recurrent ventricular tachycardias, one died of extensive myocardial infarction after being overdriven for three days at a fixed rate of 120/min. The other three had their ventricular tachycardias controlled after intermittent fixed-rate ventricular pacing for 12 to 16 days.

Of the five patients with history of strokes and chronic brain syndrome and finding of complete heart block upon admission to the hospital, three showed dramatic improvement in their mental status following temporary pacing and eventually received permanent pacemakers, whereas two were unimproved mentally and thus considered to have coexistent cerebrovascular disease and asymptomatic complete heart block. Neither patients with intractable congestive heart failure nor those with azotemia and concomitant complete heart block showed improvement of their cardiac or renal status following pacing.

Complications

There was no instance of local hematoma formation, infection, thromboembolism or myocardial perforation in the entire series of 100 consecutive patients paced by this technique.

DISCUSSION

Transvenous endocardial pacing has been in widespread use since its initial clinical report ten years ago. However, there are many approaches
and modifications of the original method. For transvenous cardiac pacing to be successful: 1. Placement of the electrode must be accomplished quickly and precisely. 2. Once properly placed within the heart the electrode should undergo little movement from the selected site of endocardial stimulation. 3. The patient, or part of his body should not be uncomfortably restrained for prevention of electrode displacement. 4. The site of venous entry for temporary pacing should not compromise later plans for permanent transvenous pacemaker implantation. 5. The procedure must be cosmetically and aesthetically acceptable to the patient. 6. The same vein should be reusable as frequently as is necessary. 7. The technique should be simple and easy to learn so that it can gain wide clinical application, and 8. the procedure must be safe.

There are currently available four basic approaches to transvenous endocardial pacing: brachial, jugular, subclavian and femoral. The brachial vein approach, which was the original route of pacing employed a decade ago, is still frequently employed because of its easy access. However, it is undesirable because the motion of the arm results in significant intracardiac electrode displacement with loss of pacing, extrusion from the right ventricle or myocardial perforation. It was shown by Escher and coworkers with cinefluorographic studies that the intracardiac displacement of a pacing electrode inserted via the brachial vein was as much as 1 to 2 inches. This electrode instability is only partially corrected by uncomfortable restraint of the patient's arm. This approach is accompanied by an increased incidence of thrombophlebitis and infection.

The jugular vein is the next most frequently employed approach for endocardial pacing. While this approach is seldom accompanied by electrode displacement, it has several disadvantages. First, this procedure is not always cosmetically and psychologically acceptable to some patients, especially the women, because it involves an operative procedure around the neck ("cut-throat" phobia) and is accompanied by an unsightly scar. Secondly, it can be time consuming, as it requires a knowledge of local anatomy, some surgical skill, considerable instrumentation and a cutdown. Thirdly, manipulation of the electrode-catheter from this site into the right atrium is not always easy, especially in the older people. Fourthly, it means permanent loss of the jugular vein and thus compromises later plans for implantation of a permanent transvenous pacemaker.

The subclavian approach, employed as a "float-in" technique, has been recently introduced as a bedside method of pacing with electrocardiographic monitoring. While this method has the main advantage of obviating the need of a fluoroscope, its disadvantages are that the placement of electrode is a blind procedure, never precise and frequently time-consuming. Accidental puncture of apical pleura resulting in pneumothorax and of subclavian artery resulting in hemorrhage and inadvertent injury to the brachial plexus have all been reported. Air embolism is a serious, though rare, hazard and can be fatal. Because the location of the electrode tip is not visualized, the adequacy of its endocardial contact cannot be assured and pacing, especially on the demand mode, can be erratic. The risk of electrode knotting, either around itself, a chorda or papillary muscle or with another permanent transvenous pacemaker catheter, though infrequent, can be serious. With the unipolar system the current level that may be used to pace is more limited and repositioning required more often than with the bipolar electrode, which, however, is accompanied by more instances of myocardial perforation.

The percutaneous transfemoral venous approach fulfills all the requirements mentioned earlier for successful cardiac pacing. Placement of electrode can be accomplished quickly, being usually completed in 3 to 13 minutes (average, 5 minutes). This technique is particularly valuable in management of patients with acute myocardial infarction complicated by A-V block or ectopic tachyarrhythmias, recurrent Stokes-Adams attacks and refractory ventricular tachycardia where expediency in establishing a stable rhythm is of paramount importance.

With the use of a fluoroscope, placement of the electrode is precise, and if the position needs to be changed or verified can be done quickly under direct visual control. Electrode displacement is infrequent. The patient is free to ambulate without any restraint. With the percutaneous technique the vein is always reusable as often as is necessary. The femoral approach does not compromise later plans for permanent transvenous pacemaker implantation which is done through either the jugular or cephalic vein. The percutaneous transfemoral approach is much more acceptable cosmetically to the patient, because it leaves no scar and the entry site at the groin is always covered by the clothing. This technique is simple and can be learned by residents or other physicians without catheterization skills. Most important of all is the fact that the procedure is safe; there was no instance of infection, thromboembolism or myocardial perforation in this series of 100 consecutively paced patients.
out risks of infection, catheter entanglement or dislodgement of a peri-electrode thrombus. Knotting of a temporary electrode around a permanent pacemaker catheter and dislodgment of a clot around or along the indwelling catheter have been reported when the second catheter was introduced along the same venous pathway as the first.

Secondly, by approaching from the femoral vein, especially if a multi-electrode catheter (Fig 3) is employed, it is a relatively simple procedure to record the electrical activity of the His bundle and thus to aid in the differential diagnosis of different forms of A-V block, including the bilateral bundle branch block. With a multi-electrode catheter which can be readily introduced percutaneously through the femoral vein by this technique, it is possible to record the His bundle electrogram without the need of meticulous catheter positioning or probing. The recording of His bundle electrogram by means of this technique is so much simplified that it can be employed routinely as a part of the diagnostic-therapeutic approach to any patient who needs transvenous cardiac pacing. For example, one patient developed acute anterolateral myocardial infarction complicated by periods of second degree A-V block which was thought to be Mobitz type II. However, it was found during temporary transfemoral insertion of a pacing catheter that the A-V block was actually Mobitz type I or Wenckebach type (Fig 4). The Wenckebach phenomenon promptly disappeared following atrope administration, and the patient was spared the discomfort of temporary pacing. The importance of distinguishing between the two types of Mobitz A-V block, type I or Wenckebach and type II, during acute myocardial infarction is not only of therapeutic importance but has prognostic significance. With a multi-electrode catheter one can also simultaneously stimulate either the right atrium or right ventricle and record the His bundle electrogram through the same catheter. Rapid atrial pacing has

Figure 3. A multi-electrode catheter in situ in the right ventricle for pacing and/or His bundle recording.

catheters are employed because of their ease of introduction and positioning, especially with a pre-formed distal end, and freedom from kinking and thus loss of endocardial contact, there has been no instance of myocardial perforation. This is due not only to the fact that there is little or no electrode displacement on motion of the lower extremity or the torso but to the design of the U-shaped bend of the distal end of the catheter which absorbs any undue force of thrust against the endocardium by buckling up at the bend.

The transfemoral venous approach has several added advantages over the other venous routes of pacing. First of all, since the intracardiac electrode is introduced through the inferior vena cava via the femoral vein and thus away from the superior vena cava which is the usual site for permanent transvenous pacemaker passage, the transfemoral approach is particularly suited for preoperative and intraoperative rhythm control during repair or replacement of a permanent transvenous unit with-
been used to separate those patients with left axis deviation and right bundle branch block as a form of bilateral bundle branch block who need demand pacing from those who do not.\textsuperscript{21}

Thirdly, atrial demand pacing has been routinely employed to prevent excessive bradycardia during coronary arteriography.\textsuperscript{23} If the pacing electrode was introduced via the inferior instead of the superior vena cava, its presence would not stand in the way as to interfere with visualization of the coronary arteries. Furthermore, if one employs the percutaneous retrograde femoral arterial approach to catheterize the coronary arteries, it will greatly simplify the procedure by merely introducing the pacing electrode through the adjoining femoral vein, thus avoiding the cumbersome need of using both the arm and leg.

REFERENCES

3. Cheng TO: Coronary sinus pacing masquerading as interventricular septal perforation by transvenous catheter. Amer J Cardiol 26:547-48, 1970

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