Ventricular Arrhythmias during Insertion and Removal of Pulmonary Artery Catheters

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The incidence and significance of the development of ventricular arrhythmias during insertion and removal of pulmonary artery monitoring catheters were determined in stable postcardiac surgical patients. Insertion of 173 (69 percent) of 250 catheters was associated with ventricular arrhythmias and removal in 158 (63 percent) of these catheters (p > 0.05). All arrhythmias resolved spontaneously. Patients who underwent valve replacement showed significantly fewer arrhythmias during withdrawal than those who underwent a coronary artery bypass operation (p < 0.025). Factors significantly influencing the incidence of ventricular arrhythmias during removal were increased postoperative CK-MB levels (p < 0.025) and cardiac index (p < 0.025).

Ventricular arrhythmias are the most common complication during the insertion of pulmonary artery (PA) catheters. It was initially believed that the balloon at the tip of the soft and flexible catheter avoids endocardial irritation and consequently the development of ventricular arrhythmias. A recent letter to the editor by Johnston et al (Chest 1984; 85:296) reported the occurrence of ventricular arrhythmias during removal of PA catheters. This study was conducted to determine the incidence and significance of ventricular arrhythmias during removal of PA catheters and to determine which factors are associated with an increased risk in stable postoperative cardiac patients.

Materials and Methods

From January to June 1984 a prospective study was conducted in 250 patients undergoing cardiac surgery who were monitored with a PA catheter. Patients who were not in sinus rhythm or had a paced ventricular rhythm or ventricular arrhythmias on their baseline electrocardiographic strip recording before insertion or removal of the catheters were excluded from the study as were patients who had to undergo repeat PA catheterization. The recorded electrocardiographic tracings were evaluated for arrhythmias in this study. The baseline electrocardiogram was recorded for 30-45 seconds.

One hour after premedication, prior to the induction of general anesthesia, PA catheters were inserted under local analgesia with lidocaine 2 percent, either by the attending anesthesiologist or by residents under supervision of the attending anesthesiologist. No intravenous lidocaine was given prophylactically. Preoperative beta blocking agents and long-acting nitroglycerin were continued until surgery. Catheters were inserted by the percutaneous Seldinger technique via the right (247 patients) or left (two patients) internal jugular vein or the left subclavian vein (one patient). After inflation of the balloon with 1.5 ml of air, 7.5 French balloon-tipped, flow-directed, heparinized VIP thermolobulation catheters (Edwards Laboratories, Santa Ana, CA) were advanced into the pulmonary artery under pressure monitoring until a reliable wedge pressure tracing was obtained.

Following a baseline electrocardiogram (ECG), recorded for 30-45 seconds, continuous ECG and pressure waveform tracings were used to record arrhythmias and assess the location of the tip during insertion.

PA catheters were removed following surgery when the patients were in a hemodynamically stable condition without the use of intravenous vasoiodulator drugs or isotropic support, and with return of adequate ventilatory function. After a baseline ECG the catheters were slowly withdrawn while an ECG-strip was continuously recorded.

The type of surgical procedure was recorded in all patients, as were complications of the insertion of the catheters, catheterization time if more than 20 minutes, the physician who performed the catheterization and the total monitoring time. In 121 patients the following variables were recorded: cardiac index; heart rate; mean right atrial pressure; pulmonary capillary wedge pressure; systolic, diastolic and mean pulmonary and systemic arterial pressures just prior to removal of the catheters; postoperative serial CK-MB enzyme levels and 12 lead ECGs twice in the first 24 hours, and daily thereafter. CK-MB levels were defined as significantly increased when a value 15 units above that measured two hours postoperatively was found at 4, 8, 12, 20, 28, 36, 44, 56 or 66 hours after the operation. Ventricular arrhythmias were defined as one or more premature ventricular complexes (PVC). Ventricular tachycardia (VT) was defined as three or more successive PVCs with a rate of more than 100 per minute. Data are expressed as median and range or as mean of the group ± 1 SD. Stepwise logistic regression analysis was used to determine which parameters significantly influenced the incidence of ventricular arrhythmias during removal. Two by two tables were analyzed using the chi-square test with the Yates correction for continuity. Statistical significance was defined as P value of less than 0.05.

Results

Epidemiologic Data

One hundred and eighty men and 70 women ranging in age from 21- to 78-years-old (median 57 years) were included in the study. The operations performed are shown in Table 1. Seventy-two catheterizations were performed by residents and 178 by anesthesiologists. The median duration of monitoring was 28 hours (range 21-126 hours).
Table 1—Incidence of Ventricular Arrhythmias during Insertion and Removal of Pulmonary Artery Catheters in 250 Patients

<table>
<thead>
<tr>
<th>Operation</th>
<th>No. of patients</th>
<th>Ventricular arrhythmias during insertion</th>
<th>Ventricular arrhythmias during removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABC*</td>
<td>205</td>
<td>144</td>
<td>135</td>
</tr>
<tr>
<td>Valve replacement</td>
<td>23</td>
<td>17</td>
<td>9†</td>
</tr>
<tr>
<td>CABC* combined with valve replacement</td>
<td>13</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

*CABC = coronary artery bypass grafting.
†p<0.05 when the incidence of ventricular arrhythmias during insertion and removal are compared in patients with valve replacement. p<0.025 when the incidence of ventricular arrhythmias during removal in patients with valve replacement is compared with coronary bypass patients or all other patients.

Ventricular Arrhythmias during Insertion

Ventricular ectopy typically occurred when the catheter tip passed through the right ventricle. The arrhythmias always resolved spontaneously and no specific therapy was required. There were no clinically important effects observed in the patients when these arrhythmias occurred. During insertion, the arrhythmias disappeared when the tip of the catheter was positioned in the pulmonary artery, and during removal as soon as the tip had passed through the tricuspid valve.

Fifty of the 72 catheters inserted by residents were associated with ventricular arrhythmias, as were 123 of the 178 catheterizations performed by anesthesiologists (p>0.05). The catheterization time was more than 20 minutes in two patients. Ventricular arrhythmias during insertion were not related to the age of the patients or the underlying heart disease. Table 2 shows the incidence and type of ventricular arrhythmias seen during insertion and removal of the pulmonary artery catheters.

Ventricular Arrhythmias during Removal

Patients who underwent a valve replacement showed significantly less ventricular arrhythmia during removal of the PA catheters than patients undergoing coronary artery bypass grafting (Table 1). However, stepwise logistic regression analysis to determine the factors which affected the incidence of ventricular arrhythmias showed no significant (p=0.648) relation between the type of surgery and the incidence of ventricular arrhythmias.

One hundred twenty-one of the 250 patients were used for stepwise logistic regression analysis. In these patients the following variables were analyzed: age, type of surgery, arrhythmias during insertion and removal, hemodynamic parameters, total monitoring time, electrocardiographic and enzyme data. Eighty-five of these 121 patients had arrhythmias during insertion and 75 during removal (p>0.05). Of these patients, 102 underwent coronary artery bypass surgery (CABG), ten valve replacement, seven CABG plus valve replacement, and two other open heart surgery. A summary of the hemodynamic data, monitoring time and age is shown in Table 3. Factors which were significantly associated with ventricular arrhythmias during removal were cardiac index (p = 0.022) and postoperatively increased CK-MB enzyme levels (p = 0.013). All other variables had p values above 0.10. Fifty-five of 76 patients with a cardiac index (CI) of less than 2.55 L/min/m² showed ventricular arrhythmias, while 23 of 45 patients with a CI>2.55 L/min/m² had arrhythmias (p<0.05). Twenty nine of 36 patients with increased CK-MB levels and 48 of 85 patients without increased enzyme levels had ventricular arrhythmias (p<0.05).

Discussion

The incidence of ventricular arrhythmias during the insertion of PA catheters in patients scheduled for cardiac surgery has varied from 37 to 65 percent in studies using continuous electrocardiographic recordings throughout the procedure. An incidence from 63 to 69 percent has been reported for critically ill patients. Number 7 French triple-lumen flotation catheters were associated with a higher incidence of ventricular premature complexes than double-lumen catheters. The use of 7.5 French catheters in this study resulted in an incidence of 69 percent arrhythmias during insertion, not significantly different from the previously reported incidence for 7 French

Table 2—Incidence of One or More Premature Ventricular Contractions (PVC) or Ventricular Tachycardia (VT) during Insertion and Removal of Pulmonary Artery Catheters in 250 Patients

<table>
<thead>
<tr>
<th></th>
<th>Insertion</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>One PVC</td>
<td>15</td>
<td>36*</td>
</tr>
<tr>
<td>Multiple PVCs</td>
<td>147</td>
<td>118†</td>
</tr>
<tr>
<td>VT</td>
<td>11</td>
<td>2‡</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>188‡</td>
</tr>
</tbody>
</table>

*p<0.001 when the incidences between insertion and removal were compared.
†p<0.025.
‡NS.
catheters.\textsuperscript{1,2,4,5} The high incidence of ventricular arrhythmias during insertion has been attributed to mechanical trauma, the severity of the underlying medical condition and an increased catheterization time.\textsuperscript{1,2,4,5} Most patients in this study were scheduled for elective coronary artery bypass surgery and were generally in a stable condition. It is suggested that the high incidence of arrhythmias during insertion of PA catheters in preoperative patients can be explained by raised levels of endogenous circulating catecholamines.\textsuperscript{3} However, significant cardiovascular stimulation by the sympathetic nervous system during the insertion of intravascular catheters can be prevented by adequate preoperative sedation and therapy with beta-blockers and nitrates maintained in full dosage until shortly before surgery.\textsuperscript{6} Thus, the high incidence during insertion of PA catheters in patients scheduled for elective cardiac surgery is either related to mechanical irritation of the endocardium or the underlying cardiac illness itself.

Removal of the PA catheters resulted in an incidence of 63 percent ventricular arrhythmias, not significantly different from the 69 percent found during insertion. Significantly fewer patients showed multiple premature ventricular complexes and ventricular tachycardia during removal (p<0.005). The development of arrhythmias during insertion of the catheters was not a significant risk factor for the occurrence of ventricular arrhythmias during removal (p=0.744). The high incidence of ventricular arrhythmias during withdrawal was found in stable postoperative cardiac patients, but it might be higher in critically ill patients. Johnston et al reported 40 percent incidence of ventricular arrhythmias during removal, significantly (p<0.025) lower than the 63 percent of this study.

Predisposing factors for the development of ventricular arrhythmias are myocardial infarction or ischemia, shock, acidosis, hypoxia, electrolyte disturbances, increased sympathetic tone and various drugs.\textsuperscript{8} One of the risk factors for the development of ventricular arrhythmias during removal of PA catheters was a raised CK-MB level in the postoperative period. Patients with a perioperative infarction do not always develop persistent new Q-waves. CK-MB, being a heart specific isoenzyme, has proven to be a reliable predictor of myocardial damage.\textsuperscript{9,11} Thus, the patients with a higher risk have at least some recent myocardial damage, which is known to be related to an increased vulnerability to ventricular fibrillation.

The cardiac index was also an important risk factor for the development of ventricular arrhythmias during removal of the PA catheters. The normal CI in the basal state varies from 2.5 to 4.2 L/min/m\textsuperscript{2}.\textsuperscript{12} At the time of PA catheter removal, cardiac index less than 2.55 L/min/m\textsuperscript{2} was found in 76 of 121 patients and was associated with significantly more ventricular arrhythmias during removal. Another risk factor can be the transit time in the right ventricle, but Johnston et al showed that this did not correlate with the frequency of PVCs if the catheter is withdrawn at a conservatively slow rate.

A significantly lower incidence of ventricular arrhythmias during removal was found in patients who underwent a valve operation. This finding was based on the data of 250 patients. However, the regression analysis, based on the data of 121 patients including only ten patients with valve replacement, did not indicate the type of surgery to be an important factor for the development of ventricular arrhythmias during removal. This may be due to the small number of patients with a valve replacement in the series used for the regression analysis. The difference in incidence of arrhythmias during catheter removal between the coronary and the valve patients could not be explained by hemodynamic parameters. It appears that coronary patients are more prone to the development of arrhythmias with catheter withdrawal than other cardiac surgical patients.

Past recommendations have stated that resuscitation equipment should be available during the insertion of PA catheters, although sustained ventricular tachycardia and ventricular fibrillation are very rare complications.\textsuperscript{9} Johnston et al recommended that PA catheters be removed under continuous electrocardiographic monitoring. In addition, it is probably recommendable to take the same precautions during removal as during insertion.

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