of summation of impulses which is strong enough to cross the block. This may play an important role in high-degree atrioventricular block. The previously mentioned two effects may act together to make retrograde conduction possible. As to ventricular contractions from the ectopic pacemakers, impulses below the block give rise to mechanical or electrotonus effects to activate the area above the block, and the hypothesis of dual conduction pathways is merely conjectural.

In the present case, defects of the atrioventricular junction as well as the atra were possible; when intra-atrial block is present, the following may occur: (1) sinus impulses reach the lower part of the right atrium and then cross over to activate the left atrium through the atrial muscle; and (2) the left atrium does not depolarize. The latter probably was the case in the present report. In leads 2 and Vn, narrow and peaked P waves intermittently appeared, denoting third-degree intra-atrial bundle-branch block; the peaked P waves signified that the right atrium was activated, while left atrium was not depolarized.

REFERENCES

Right-to-left Shunt Through Patent Foramen Ovale Complicating Right Ventricular Infarction*

Successful Percutaneous Catheter Closure

Steven K. Krueger, M.D.; and Donald L. Lappé, M.D.

A patient with right ventricular infarction and severe hypoxemia secondary to right-to-left shunting through a patent foramen ovale is presented. A balloon tip catheter was positioned in the left atrium and retracted against the atrial septum and the hypoxemia resolved. (Chest 1988; 94:1100-01)

Right ventricular infarction is common and potentially lethal. Recognition and correct treatment frequently result in short-term survival which usually becomes long-term success. Therefore, optimal treatment is essential.

*From the LDS Hospital, and the University of Utah, Salt Lake City

Patent foramen ovale is common and benign unless right atrial pressure (RAP) exceeds left atrial pressure (LAP) and right-to-left shunting of blood or clot ensues. Right ventricular infarction frequently results in increased RAP and right-to-left shunting has been reported.

We report a patient with right ventricular infarction, patent foramen ovale, significant hypoxemia secondary to right-to-left shunting, successfully treated with short-term percutaneous catheter closure of the patent foramen ovale.

CASE REPORT

A 74-year-old man was admitted with acute inferior myocardial infarction with CK elevation to 2,963 with 16 percent MB. Temporary ventricular pacing was instituted for sinus bradycardia. Hypotension refractory to 2 L of intravenous fluid required therapy with dobutamine. Renal failure and confusion developed. Arterial blood gas determinations showed PaO2 = 65 mm Hg on 70 percent O2 by mask. There was no preexisting pulmonary disease. Physical examination was remarkable for confusion and jugular venous distention. Chest x-ray film showed pulmonary venous congestion. The electrocardiogram showed acute inferior myocardial infarction and 1 mm ST-T segment elevation in V1.

The next six days were marked by persistent hypotension requiring therapy with dobutamine. The cardiac index was 1.94, right atrial pressure = 23 mm Hg, and pulmonary capillary wedge pressure, 19 mm Hg and stable. An echocardiogram with contrast showed severe posterior and right ventricular hypokinesis and right-to-left crossing of contrast at the atrial level.

The PaO2 level dropped to 45 mm Hg on 100 percent O2 and the patient underwent cardiac catheterization (results in Table 1). Angiography showed inferior hypokinesia, 100 percent obstruction of the proximal right coronary artery (RCA), 60 percent stenosis of the first diagonal and 60 percent stenosis of the proximal left anterior descending (LAD).

A Gemini catheter was advanced through the patent foramen ovale and exchanged over a guidewire for a 5F Swan-Ganz catheter. The balloon was inflated with a dilute contrast medium and the catheter retracted until resistance was met. The PaO2 rose to 98 mm Hg on 100 percent FIO2. The catheter was anchored to the leg with a rubber band. Anticoagulation was accomplished with IV heparin infusion.

The next 12 days brought no significant change with right atrial pressure remaining higher than the left, and the patient remained in shock with cardiac index = 1.52, RAP = 25-12 mm Hg, LAP = 15-8 mm Hg despite adequate oxygenation. The PaO2 remained between 64 and 89 mm Hg on 50-60 percent O2.

Despite the poor prognosis, coronary bypass grafts to the first diagonal, LAD and RCA were constructed and the patent foramen ovale was sutured closed.

The patient did well initially. However, mild hypotension continued and did not improve with varying pacing rates, and therapy with dobutamine or isoproterenol. He developed pneumonia, sepsis, worsening hypotension and died.

DISCUSSION

Right-to-left shunting through the patent foramen ovale has been reported in the adult respiratory distress syndrome, pneumonectomy, and coronary artery bypass graft surgery, as well as RV myocardial infarction. The incidence of right-to-left shunting and RV myocardial infarction is not known, but could approach the incidence of patent foramen ovale (25 percent). Patients with RV myocardial infarction and hypoxia should be investigated for right-to-left shunting with contrast echocardiography, Doppler, indicator dye curves or O2 saturation studies.
Table 1—Result of Cardiac Catheterization

<table>
<thead>
<tr>
<th>Site</th>
<th>Pressure</th>
<th>O₂ Saturation</th>
<th>PO₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrium</td>
<td>22-22 (19)</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Right ventricle</td>
<td>32/17-22</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Pulmonary artery</td>
<td>32/22 (98)</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Pulmonary vein</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left atrium</td>
<td>21-22 (19)</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Aorta</td>
<td>140/84 (106)</td>
<td>93</td>
<td>65 (100% FIO₂)</td>
</tr>
<tr>
<td>Left ventricle</td>
<td>140/10-22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac output</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac index</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right-to-left</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>by Cardiogreen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-closure of PFO</td>
<td></td>
<td></td>
<td>286 (100 FIO₂)</td>
</tr>
<tr>
<td>Right-to-left shunt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Cardiogreen</td>
<td></td>
<td></td>
<td>resolved</td>
</tr>
</tbody>
</table>

Recognition of the right-to-left shunt mandates careful handling of intravenous lines to avoid systemic air or particulate emboli.

The percutaneous catheter closure technique used in this case is not technically difficult, and resulted in remarkable resolution of hypoxemia. We feel it should be attempted when significant hypoxemia complicates right-to-left shunting through the atrial septum. The rubber band suture may have contributed to the catheter's excellent stability.

Systemic embolization is a potential complication of this procedure. Careful handling of the catheter and possibly anticoagulation should minimize risk.

Resolved hypoxemia, improved hemodynamics (RAP/LAP ratio) or disappearance of the early circulation pattern of the dye curve with the balloon deflated indicates the time for balloon removal.

Failure to close the patent foramen ovale, persistent right atrial hypertension and continued right-to-left shunting may indicate the need for surgical closure despite the high risk.

In summary, we present a patient with RV infarction and severe hypoxemia secondary to right-to-left shunting through a patent foramen ovale successfully treated short-term with percutaneous catheter closure. This technique should be considered when significant right-to-left shunting complicates RV infarction.

REFERENCES

Legionella Pneumonia Complicating Wegener's Granulomatosis*

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A. Gordon Letch, B.Sc., M.B., Ch.B., Ph.D., F.C.C.P.,§
G. J. Ross McHardy, M.A., B.Sc., B.M., B.Ch.‡

We describe a previously healthy man who presented with features consistent with Wegener's granulomatosis. While undergoing investigation, he developed acute respiratory failure, thought to represent progression of his vasculitis. Open lung and sinus biopsies were performed to obtain the diagnosis. Vasculitis was confirmed on the para nasal biopsy, and the lung biopsy showed pneumonia due to Legionella pneumophila, an association not previously reported in Wegener's granulomatosis. If immunosuppressive therapy had been started without making the diagnosis of Legionella pneumonia on lung biopsy, the patient might well have succumbed to the infection. (Chest 1998; 94:1101-03)

Wegener’s granulomatosis is an uncommon multisystem disease in which necrotizing granulomatia of the upper and lower respiratory tract are found in conjunction with a small-vessel vasculitis and glomerulonephritis. One of the many features is an increased susceptibility to infections, especially staphylococcal sinusitis and atypical infections, many probably related to immunosuppressive therapy.† We describe severe Legionella pneumonia prior to immunosuppressive treatment, an unreported association.

CASE REPORT

A previously healthy 47-year-old male lecturer who smoked 40 cigarettes per day, was admitted to the hospital for investigation of chest pain, breathlessness, deafness, and loose stools. The breathlessness had begun insidiously about one month earlier and was progressive but not disabling. It was associated with chest pain which was neither cardiac nor pleuritic in nature. Over a similar period the patient noticed increasing left-sided deafness and loose stools which contained blood and mucus. In the week prior to

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