Cardiac Tamponade due to Hypertonic Contrast Medium in the Pericardial Sac Following Cineangiography

Clinical Observation and Experimental Study

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SUMMARY

Relatively small amounts of contrast media reaching the pericardial sac can cause acute cardiac tamponade. The mechanism of this complication is on the basis of the hyperosmolarity of these angiographic media, resulting in the further accumulation of large amounts of fluid in the pericardial sac. Active bleeding due to possible perforation has probably not been a major factor in the cases reported. The appearance of contrast medium in the pericardial sac should alert the cardiac catheterization team to the possibility of impending severe cardiac tamponade, and pericardiocentesis should be prepared for immediately. Thoracotomy is probably not necessary in the majority of cases.

Additional Indexing Words:

Open-heart surgery Pericardiocentesis Hypaque Thoracotomy
Renografin Pulmonic stenosis Urokon Patent ductus arteriosus

It is recognized that selective angiocardiography by means of rapid, high pressure injection via a cardiac catheter results in a 5% incidence of myocardial extravasation. The majority of these mishaps are clinically asymptomatic, although a rare fatality has been reported. Cardiac tamponade due to faulty contrast medium injection has been recognized far less often and its mechanism has not been fully explained. The purpose of this communication is to present an example of severe and nearly fatal cardiac tamponade following right ventricular cineangiography and give the results of animal experiments that prove the etiology and point to the correct treatment for this complication.

Case History

D. W., an asymptomatic 6-months-old infant girl, was referred to the cardiac catheterization laboratory at Presbyterian Medical Center for hemodynamic study. She weighed only 11 pounds 6 ounces, having weighed 4 pounds 5 ounces at birth. It was thought that she might have pulmonic stenosis and a ventricular septal defect. There was no cyanosis.

Right heart catheterization was performed on May 11, 1965, via the right saphenous vein. The infant was given 5 mg of Demerol intramuscularly, 30 minutes before reaching the laboratory. The right ventricular pressure was found to be 125/11 mm Hg with a simultaneous femoral artery pressure of 110/54. Femoral artery oxygen saturation was 90%, left atrial oxygen saturation 90%, pulmonary vein oxygen saturation 94%. The catheter passed across a patent foramen ovale. With crying, the right ventricular pressure was well over 200 mm Hg systolic. The catheter could not be manipulated easily into the pulmonary artery, and it was suspected that an intact ventricular septum was probably present. Further attempts at this were abandoned, and preparations were made for a cineangiogram with right ventricular injection.

A no. 6 N.I.H. angiocatheter was guided to the right ventricle from the saphenous vein. The
tip was placed at the apex and somewhat anteriorly. Two cubic centimeters of 75% Hypaque (sodium diatrizoate) were injected by hand as a test dose, the injection being observed with the image intensifier and fluoroscope. The contrast medium was easily visualized, and no myocardial injection noted. In retrospect, the observers are not certain whether the catheter tip was entirely free. Nine cubic centimeters of 75% Hypaque were then injected by means of a 50-cc syringe with Enasco injector, with chamber pressure set at 90 lb/in\textsuperscript{2} and a mechanical advantage of 9, thus resulting in a proximal end catheter pressure of approximately 800 lb/in.\textsuperscript{2}. Friction loss in our system is high.

The injection was monitored via a television screen and it became evident, very early in the run, that an appreciable amount of the contrast medium was injected into the myocardium. The patient became restless immediately, and the electrocardiogram revealed profound ST depression in lead II. Further fluoroscopy revealed persistence of contrast medium in the anterior wall of the right ventricle and the accumulation of this substance in the pericardial sac. Two minutes after the injection, another short cine strip was taken and the catheter withdrawn to the right atrium. During the next 5 minutes, right atrial pressure rose to 20 mm Hg, mean, and the femoral artery pressure dropped so that it could barely be felt. The preinjection right atrial mean pressure was 7 mm Hg. Oxygen was administered by mask, and the anesthesia as well as heart-surgery team were alerted. Preparations were made for pericardiocentesis or thoracotomy. Fifteen minutes after the injection, the infant became unconscious and severe bradycardia developed with apparent further progression of tamponade. After careful consideration, it was elected to perform a right thoracotomy and at the same time 5 mEq of sodium bicarbonate and 6 mcg of isoproterenol were given via the catheter because of nearly complete cardiac standstill. A tight pericardium was found, and incision produced a clear, slightly pink fluid, under great pressure. It was not possible to measure the volume, but the surgeon estimated it to be well over 20 cc. The myocardium barely contracted, but with further isoproterenol and cardiac massage the heartbeat returned and within 2 minutes a good femoral pulse was palpated. The pericardium was irrigated and left wide open. Inspection revealed no myocardial injury. The electrocardiogram, lead II, returned to preinjection configuration and the chest was closed.

The patient made an uneventful recovery and was discharged 10 days later. Open-heart surgery was performed 10 months later, at which time the primarily valvular pulmonic stenosis was relieved and a patent ductus arteriosus closed. There were pericardial adhesions, but careful inspection revealed no right ventricular myocardial scarring as might have been caused by a possible perforation by the catheter.

Comment

The quality of pericardial fluid obtained at the time of thoracotomy was a surprise. It was clear that the bleeding had not caused the tamponade, as the fluid was only slightly blood tinged. Furthermore only a total of 9 cc of 75% Hypaque had been injected and after viewing the cineangiogram (fig. 1), it was clear that no more than half of it had been injected into the myocardium. Some myocardial dye was present by 1/60 of a second, and the injection was completed by ½ a second. A minute amount of pericardial dye was visible at 3 seconds, and it was not until approximately 1 minute later that an appreciable amount of Hypaque was seen in the pericardial sac. It was therefore thought that the contrast medium injected into the myocardium may have caused minute perforations and arrived at the epicardium from where it gradually seeped into the pericardial sac. Furthermore, the osmolarity of 75% Hypaque is nearly eight times that of serum,\textsuperscript{2} causing further fluid to be drawn into the pericardial sac, eventually causing tamponade.

To test this hypothesis, it was decided to take the problem into the experimental animal laboratory.

Method

Thirteen dogs, ranging in weight from 9.5 kg to 16.8 kg, were anesthetized with Nembutal (sodium pentobarbital). Thoracotomy was performed, and a size 8 Bardic “Resiflex” infant feeding tube was inserted into the pericardial sac via a small incision. This was tightly sutured, and the feeding tube was brought via a separate incision to the back of the animal. The feeding tube was filled with heparin and clamped. The animals were allowed to recover over at least a 3-day period and then reanesthetized. The pericardial tube was found to be patent, and all fluid was aspirated. With right atrial (via a femoral vein catheter advanced to the right atrium) and femoral artery pressures and electrocardiogram being monitored, radiopaque contrast medium was injected into the pericardium. Pressures were recorded by means of Statham gauges P23AA and P23Db and an Electronics for Medicine Recorder.

In the first series of seven dogs, 0.5 cc/kg was given initially, followed by 0.25 cc/kg every 4
Figure 1
Cineangiogram with patient in lateral position. Upper left. Four-sixtieth of a second after beginning of injection. Upper right. Extension of contrast medium into anterior wall of right ventricle. Lower left. Two seconds after injection; contrast medium is draining from myocardium via coronary vein into coronary sinus. Lower right. Two minutes after injection; contrast medium is in the pericardium.
minutes (table 1). Hypaque, 75%, was used for three dogs and Renografin, 76% (methylglucamine diatrizoate), for the subsequent four dogs. Pressures were recorded before each pericardial infusion. A rise of 3 mm Hg mean in right atrial pressure and a significant fall in the femoral artery mean pressure (at least 15 mm Hg) were used as the end-point of the experiment and the development of tamponade. The pericardium was then aspirated via the same feeding tube and the volume carefully measured. In most of the dogs, this end-point was reached after 1 hour, although 2 hours were required in the case of dog no. 2.

In the second series of six dogs, only one injection of contrast medium was infused. As indicated (table 2), only 1 or 2 cc/kg were used and pressures again recorded every 4 minutes. The same criteria for an end-point were used; this was uniformly reached at 25 to 35 minutes after infusion. The pericardium was then aspirated and, if difficulty was encountered, thoracotomy was performed and an attempt made to collect and measure the "gel" that had formed in the pericardium.

Results
As can be seen in tables 1 and 2, the ratio of contrast medium injected to volume aspirated was nearly 3:1 or greater in the first series. The specific gravity of this fluid was 1.160 compared to 1.033 of whole blood. In the second series, some dogs had a greater ratio although the results were uneven because of the "gel" that had formed in the pericardial space, not allowing accurate measurement. It was considered that this proved our hypothesis that the hyperosmolarity of the contrast medium was responsible for a larger and fairly rapid fluid accumulation in the pericardial sac, resulting in tamponade.

Discussion
A review of the literature reveals several reports of contrast medium reaching the pericardium in patients having angiography. In some instances, this occurs when an injection is made via a needle inserted into the left

Table 1
Pericardial Fluid Following Repeated Small Injections

<table>
<thead>
<tr>
<th>Dog no.</th>
<th>Weight (kg)</th>
<th>Medium</th>
<th>Injected (cc)</th>
<th>Solution used (cc)</th>
<th>Aspirated (cc)</th>
<th>Ratio: injection* aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.8</td>
<td>Hypaque, 75%</td>
<td>15</td>
<td>5</td>
<td>60</td>
<td>1:3.7</td>
</tr>
<tr>
<td>2</td>
<td>16.2</td>
<td>Hypaque, 75%</td>
<td>28</td>
<td>8</td>
<td>97</td>
<td>1:3.2</td>
</tr>
<tr>
<td>3</td>
<td>12.2</td>
<td>Hypaque, 75%</td>
<td>36.1</td>
<td>11</td>
<td>125</td>
<td>1:3.2</td>
</tr>
<tr>
<td>4</td>
<td>13.6</td>
<td>Renografin, 76%</td>
<td>32.7</td>
<td>9</td>
<td>100</td>
<td>1:2.8</td>
</tr>
<tr>
<td>5</td>
<td>9.5</td>
<td>Renografin, 76%</td>
<td>21.5</td>
<td>8</td>
<td>Aspiration unsuccessful</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>14.5</td>
<td>Renografin, 76%</td>
<td>35.2</td>
<td>9</td>
<td>103</td>
<td>1:2.7</td>
</tr>
<tr>
<td>7</td>
<td>13.1</td>
<td>Renografin, 76%</td>
<td>32</td>
<td>11</td>
<td>101</td>
<td>1:2.8</td>
</tr>
</tbody>
</table>

*Ratio: \( \frac{\text{cc's of media injected}}{\text{cc's aspirated - cc's flush solution used}} \)

Table 2
Pericardial Fluid Following a Single Injection

<table>
<thead>
<tr>
<th>Dog no.</th>
<th>Weight (kg)</th>
<th>Medium</th>
<th>Injected (cc)</th>
<th>Solution used (cc)</th>
<th>Aspirated (cc)</th>
<th>Ratio: injection* aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>10.9</td>
<td>Hypaque, 75%</td>
<td>11</td>
<td>2</td>
<td>Aspiration unsuccessful</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>13.0</td>
<td>Renografin, 76%</td>
<td>26</td>
<td>1</td>
<td>87 + gel†</td>
<td>1:3.4</td>
</tr>
<tr>
<td>10</td>
<td>11.0</td>
<td>Hypaque, 75%</td>
<td>22</td>
<td>2</td>
<td>47 + gel</td>
<td>1:2.0</td>
</tr>
<tr>
<td>11</td>
<td>14.5</td>
<td>Renografin, 76%</td>
<td>14.5</td>
<td>1</td>
<td>72</td>
<td>1:4.9</td>
</tr>
<tr>
<td>12</td>
<td>10.5</td>
<td>Hypaque, 75%</td>
<td>10.5</td>
<td>1</td>
<td>41 + gel</td>
<td>1:3.9</td>
</tr>
<tr>
<td>13</td>
<td>16.8</td>
<td>Hypaque, 75%</td>
<td>33.6</td>
<td>1</td>
<td>80 + gel</td>
<td>1:2.3</td>
</tr>
</tbody>
</table>

*Ratio: \( \frac{\text{cc's of media injected}}{\text{cc's aspirated - cc's flush solution used (gel not included)}} \)

†The "gel" was coagulated, nonliquid, clear, viscous material obtained from the pericardial sac along with the fluid. The extreme variation of the injection-to-aspiration ratios may be explained by the presence of this coagulated material, which could not be aspirated with a syringe.
ventricle percutaneously; in others, the injection is made via an open end-hole or closed end-hole catheter (as in our case), placed in one or the other of the two ventricles.

Clinical signs of cardiac tamponade appeared in a patient described by Hilbish and Herdt. This was a 37-year-old man with mitral disease in whom 70% Urokon (same osmolarity as 75% Hypaque) was used. Tamponade increased over a 3-hour period and thoracotomy was performed. No particular bleeding point was mentioned, and the pericardial fluid was not described in detail. He made an uneventful recovery. The patient described by Levin and associates is similar to ours in many respects except that the lesion was aortic stenosis and the injection was made in the left ventricle. Thirteen cubic centimeters of 75% Hypaque were injected via an N.I.H. (closed end-hole) catheter. The blood pressure dropped immediately and 5 minutes later 65 cc of blood-stained fluid were aspirated from the pericardial sac by percutaneous needle puncture. Those authors thought that perforation occurred.

Our animal experiments and a review of the previously mentioned reports make it clear that active bleeding is not likely to be the cause of tamponade in this situation. Whether clinical signs of tamponade will occur depends upon the amount of pericardial fluid already present, the amount of hypertonic contrast medium reaching the pericardial space and drawing in more fluid, and the type of heart disease present. We have seen patients with only the mildest signs of tamponade having a pericardial effusion of over 900 cc. On the other hand, patients with severe outflow-tract obstruction are probably very sensitive to a rapid change in the pericardial pressure, which in turn interferes with ventricular filling pressure. In our second series of animals, the single-injection experiment used amounts of contrast medium considered at the upper limits for clinical angiography injections. Considering the fact that these were healthy animals, it is significant that the clinical signs of tamponade did occur, even though fatal tamponade would probably not have developed if this experiment had been allowed to continue and the fluid not aspirated.

We have not discussed the technical aspects of faulty contrast-medium injection, as this has been covered adequately in previous communications. We believe that all the accepted precautions were taken in our patient and that the force of injection may well have wedged the catheter tip in the heavily trabeculated myocardium. Since this occurrence, we are now performing a test pressure injection of 1 or 2 cc of contrast medium whenever we are the least suspicious of catheter impingement. This can be carried out with ease by the Ensco injector, and the catheter does not have to be disconnected for the final injection.

This study, as well as a review of the literature, indicates that if clinically severe tamponade results after the deposition of hypertonic contrast medium in the pericardial sac, it will occur most likely within the first hour and probably no later than 3 to 4 hours.

**Acknowledgment**

The authors wish to express their appreciation to Dr. William Anderson, Department of Radiology, Presbyterian Medical Center, San Francisco, for his advice and criticism.

**References**


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Circulation. 1967;35:933-937
doi: 10.1161/01.CIR.35.5.933

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