The Giant "A" Wave of the Left Atrial Appendage

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I
n an exploration of the left atrium via an atrial septal defect during a recent cardiovascular catheterization in this laboratory, the catheter tip entered the left atrial appendage. An exaggerated "a" wave observed in the pressure contour from the left atrial appendage was striking and exceeded in amplitude the "a" wave from the left atrium proper. Following a similar observation thereafter in a second patient with a patent foramen ovale, a concerted effort was made to enter the appendage on all subsequent catheterizations of the left atrium. To our knowledge, there is no other report in the literature regarding pressure contour in the left atrial appendage. "Falsey" elevated pressure curves from the right atrial appendage\(^1\) and right atrium\(^2\) have, however, been observed.

Methods

Attempts to introduce the catheter into the left atrial appendage were made in 14 patients besides the two that prompted the study. These 14 patients included one with patent foramen ovale, four with ostium secundum, and one with ostium primum defects of the atrial septum, eight with rheumatic mitral stenosis or insufficiency, and one with myocardiitis.

In order to estimate the frequency of inadvertent catheterization of the left atrial appendage, left atrial pressure tracings recorded from a similar group of 15 patients over a 15-month period prior to the initiation of this study were reviewed with particular attention to pressure contour.

Standard technics were employed in all cardiac catheterizations. Catheters for left-heart catheterization were introduced percutaneously.\(^3,4\) Transseptal left atrial puncture was performed by the technic described by Ross et al.\(^5\) except in two cases, in which the Brockenbrough modification\(^6\) of this technic was used. The catheter was advanced over the transseptal needle into the left atrium.\(^7\) Catheter position was monitored fluoroscopically at all times with a nine-inch image intensifier,\(^8\) and cineangiograms were taken with an attached 35-mm. camera during injection of Hypaque (sodium diatrizoate) 75 per cent with a Gidlund power syringe.\(^9\) All pressures were recorded with Statham D strain gages\(^4\) and a multi-channel photographic recorder.\(^6\)

Results

The giant "a" waves in the left atrial appendage pressure tracing are compared with those in the left atrium proper in the first patient (G.M.), shown in figure 1. Figure 2 confirms the position of the catheter tip in the left atrial appendage in this patient. A pressure tracing as the catheter tip was withdrawn from the left atrial appendage into the left atrium proper in another patient is demonstrated in figure 3.

The catheter tip was successfully introduced into the left atrial appendage in four of 31 patients in whom left atrial catheterization was performed. In each of the four cases in which the left atrial appendage was entered, the catheter was introduced into the left atrium via a septal defect or a patent foramen ovale (table 1). In no case in which the left atrium was catheterized by the transseptal puncture technic, including the Brockenbrough modification, could the catheter tip be introduced into the left atrial appendage.

Review of the left atrial pressure tracings from all previous catheter studies revealed no incidence of pressure contour characteristic of that in the left atrial appendage.

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The opinions or assertions contained herein are those of the authors and are not to be construed as official or reflecting the views of the Navy Department or of the Naval Service at large.
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Discussion

Catheterization of the left atrium is commonly performed in the cardiac catheter laboratory today. The left atrium is entered most frequently by the transseptal puncture technic, but also via a defect in the atrial septum, a patent foramen ovale, and rarely in retrograde direction from the left ventricle. Since the catheter may be introduced into the left atrial appendage inadvertently in diagnostic studies, the finding of a giant "a" wave in that location assumes importance. It is of particular significance since the "v" wave is the most prominent wave in normal left atrial tracings and the recent finding of prominent "a" waves in the left atrium associated with congenital aortic stenosis.

The discovery of a giant "a" wave in a pressure tracing from the left atrial appendage and the demonstration of the catheter

Table 1

Summary of Catheterizations of the Left Atrial Appendage in 31 Catheterizations of the Left Atrium by Various Technics

<table>
<thead>
<tr>
<th>Technic</th>
<th>Catheter route*</th>
<th>Left atrium</th>
<th>Left atrial appendage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent foramen ovale</td>
<td>SVC</td>
<td>1</td>
<td>1 (C.J.)</td>
</tr>
<tr>
<td></td>
<td>IVC</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Ostium secundum</td>
<td>SVC</td>
<td>8</td>
<td>1 (S.H.)</td>
</tr>
<tr>
<td></td>
<td>IVC</td>
<td>2</td>
<td>1 (G.M.)</td>
</tr>
<tr>
<td>Ostium primum</td>
<td>SVC</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>IVC</td>
<td>2</td>
<td>1 (W.C.)</td>
</tr>
<tr>
<td>Transseptal puncture</td>
<td>Ross</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Brockenbrough</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Retrograde from left ventricle</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>31</td>
<td>4</td>
</tr>
</tbody>
</table>

*SVC, superior vena cava; IVC, inferior vena cava.

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tip location by contrast media in the first two cases were fortuitous. Confirmation of this observation on every occasion in which the left atrial appendage has knowingly been entered indicates that a giant "a" wave is a frequent if not invariable finding in the left atrial appendage.

At the present time there is no apparent explanation of the giant "a" wave observed in the left atrial appendage. Similar pressure waves in the right atrial appendage were ascribed to pressure of the catheter tip against the wall of the appendage.\(^1\) Fowler et al.\(^2\) observed identical pressure curves from the right atrium and believed that this was an artifact induced by motion of the catheter tip.

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**Figure 2**

*Single cineangiocardiographic frames demonstrating opacification of the left atrial appendage in the same patient as in figure 1. The catheter courses from the inferior vena cava across an atrial septal defect with the tip in the left atrial appendage. Two other catheters are seen: a catheter from the arm traversing the right heart with the tip in the pulmonary artery, and a retrograde aortic catheter with the tip in the aortic root. Note the motion of the appendage that occurred between A (left) and B (right).*

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**Figure 3**

*Disappearance of the giant “a” wave as the catheter tip was withdrawn from the left atrial appendage into the left atrium proper.*
Figure 4

Artifact that may appear in a left atrial pressure tracing at the mitral valve. These exaggerated pulse waves begin after the initial portion of the QRS complex of a simultaneous electrocardiogram.

against the atrial wall. In retrospect, a review of the right atrial pressure tracings in Fowler’s paper suggests that the catheter tip was most likely in the atrial appendage rather than in the atrium. This phenomenon is not believed to represent the catheter tip tapping against the wall of the appendage, since this would be expected to produce damping of pressure, as occurs frequently in the ventricle. In addition, the catheter tip was demonstrated to lie free in the cavity of the left atrial appendage by cineangiography (fig. 2) and by free withdrawal of blood through the catheter. No doubt the relatively greater systolic activity of the atrial appendage compared with the atrium proper and the size of the communication with the atrium proper are factors in the production of the giant “a” wave.

Failure to introduce the catheter into the left atrial appendage in any case by use of the transseptal puncture technic may be due to the relative stiffness of the Teflon “sleeve” catheter used. Utilization of a more flexible catheter should facilitate exploration of the left atrium. Entry into the left atrial appendage would be unexpected during use of the Brockenbrough modification of the transseptal technic, since the fixed curve in the catheter would direct the tip away from the appendage. Whether the catheter coursed across the atrial septum from the superior or inferior cava appeared to have no effect, in this small series, on entry into the left atrial appendage (table 1).

Careful exploration of the left atrium, including the pulmonary veins, has not revealed a similar giant “a” wave with a normal mean left atrial pressure in any location other than the atrial appendage. After review of many pressure tracings, however, two situations that could produce a giant atrial pressure wave.

*United States Catheter & Instrument Corporation, Glens Fall, New York.
Simultaneous recording of right atrial and right ventricular pressures and electrocardiogram demonstrates the giant atrial pulse wave resulting from valvular insufficiency associated with a premature ventricular contraction.

Wave with a normal mean atrial pressure were noted. The first is the artifact produced at the mitral valve (fig. 4). This may be differentiated from the giant "a" wave by its initial upstroke occurring after the beginning of the QRS complex on a simultaneous electrocardiogram. The second (fig. 5) is the atrial pressure wave produced by valvular insufficiency, whether due to an obvious premature ventricular contraction as in this case or otherwise. Timing of the atrial pressure wave with a simultaneous electrocardiogram should accurately define a giant "a" wave in any circumstance.

Summary
Giant "a" waves, not present in any other location in the left atrium, were recorded in four cases in the left atrial appendage. The location was confirmed by cineangiography.

Acknowledgment
The authors wish to express appreciation to Mrs. S. E. Brooks and to the Medical Photography Laboratory, U. S. Naval Hospital, Portsmouth, Virginia, for their help in the preparation of this paper.

Addendum
Since this paper was submitted for publication the left atrial appendage has been entered with the catheter tip in five of six left atrial catheterizations. This number includes three patients with secundum atrial septal defects, one patient with a patent foramen ovale crossed via the inferior vena cava route, and one patient in whom the left atrium was entered via transseptal puncture by use of the Ross technic. On each occasion the characteristic giant "a" wave of the left atrial appendage was observed and recorded. The only unsuccessful attempt to enter the left atrial appendage occurred in a patient with a secundum atrial septal defect crossed via the superior vena cava route.

References
1. JOHANSSON, B. W., AND OHLSSON, N.-M.: Falsely high pressure curve from the right atrial ap-


The Capillary Circulation

The tercentenary of the birth of Marcello Malpighi, the father of histology, on 10 March 1628 and that of the De Motu appropriately coincide, for in 1661 he provided the final proof of Harvey's discovery by recognizing the capillaries in the frog's lung. He also saw the red blood corpuscles in the mesenteric vessels of a hedgehog, but as he regarded them as fat cells, Antony van Leeuwenhoek, "the immortal Bedell" as B. Ward Richardson christened him, who described them fully in his True Circulation of the Blood in 1666, has the credit of their recognition. Johannes Swammerdum, however, had actually noted the presence of red blood cells as early as 1658, but his observation was not made public until 1738 when Boerhaave brought out Swammerdum's Biblia Natuerae. Luciani gives the credit of first seeing with a microscope the red corpuscles in the capillaries of a living animal (an embryo chick) to Lazzaro Spallanzani in 1771.—Sir Humphry Davy Rolleston. The Harveian Oration. Great Britain, Cambridge University Press, 1928, p. 8.
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