The Limbic Ledge

A Landmark for Transseptal Left Heart Catheterization

By Dennis A. Bloomfield, M.B., and Bruce C. Sinclair-Smith, M.B.

Since its initial description, transseptal left heart catheterization has been increasingly used as a diagnostic and a research technic.

While refinements in instrumentation have emerged, the method of septal puncture has remained unchanged. The original description of septal puncture required that the catheter and needle assembly be positioned in the right atrium at a point near the junction of the lower and middle thirds of the atrium against the septal wall. With the tip pointing posteriorly and to the left, the needle was unsheathed and passed through the septum into the left atrium. The uncertainty and anxiety in locating the best puncture site are implied by Cope and Aldridge who have used the aortic valve, visualized by a retrograde aortic catheterization as an indirect aid to septal puncture site, but to our knowledge no direct, right atrial landmark has been utilized for this objective. In addition no modification of the puncture site has been suggested to accommodate the anatomic variations found in abnormal hearts.

This paper describes an aid to transseptal catheterization based on the identification of the limbus fossa ovalis, the ledge overhanging the fossa. The application of this modified technic and its increased safety are presented in a series of 145 patients.

Method

After standard percutaneous right femoral vein insertion, the sheathed Brockenbrough needle is advanced with the tip directed to the patient's right into the orifice of the superior vena cava (fig. 1A). It is then gently rotated clockwise until the tip points to the left posterior position while being withdrawn down the atrial septum (fig. 1B and 1C). Suddenly and with an unmistakable jump to the left, the catheter tip clears the limbic ledge (fig. 1D). This leftward movement can be well appreciated both visually and tactually. The movement is usually finely demarcated, precise, and quite dramatic. No other

Figure 1

Stages of positioning the transseptal catheter for localization of the limbic ledge. The dotted line represents the position of the tip of the catheter as it is drawn down the septum. A. Turned to the right in the lower superior vena cava. B. Turning anteriorly at the superior vena caval right atrial junction. C. Turned to the left, in apposition with the upper interatrial septum. D. Turned left and posteriorly, resting on the floor of the fossa ovalis. The catheter tip has just moved to the left ovalis. The catheter tip is represented by the sharp angle in the dotted line. E. Across the septum and into the left upper pulmonary vein.

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similar movement with which this could be confused can be elicited over the length of the septum with the needle tip directed, as stated, to the left posterior. Immediately the upper rim of the fossa ovalis has been cleared the catheter is gently rotated anteriorly and posteriorly two or three times, and in two thirds of our cases it crosses gently to the left side without the necessity of puncturing the septum with the needle. Only light pressure against the septum, less than is customary for anchoring the catheter while advancing the needle for the usual septal puncture, is required. Once in the left atrium the catheter invariably enters a pulmonary vein (fig. 1E) a very short distance from the point of septal crossing. Withdrawal of the catheter to free it from the ostium of the vein appears to risk its return to the right side, but if a counterclockwise rotation is applied to the catheter before withdrawal, it swings anteriorly when free from the vein and the curve of the tip carries it down and through the mitral valve in one movement.

**Results**

The Brockenbrough technic of transseptal catheterization has been carried out in 145 patients. In 106 of these (63 per cent) passage of the catheter to the left atrium has been achieved without unsheathing the needle by the method described. An analysis of the results is given in table 1.

One hundred and thirteen patients had chronic rheumatic valvular disease. The principal lesion in 46 was mitral stenosis, in 10 mitral insufficiency, and in 15 both stenosis and insufficiency were of equal hemodynamic importance. Eleven had aortic stenosis, 15 had aortic insufficiency, and 16 had a mixed lesion of the aortic valve. Eight patients had primary myocardial disease. In all of them, end-diastolic pressures were elevated in both ventricles and no valvular disease was demonstrated. Eleven patients had congenital heart disease, two with ventricular septal defects, two with pulmonary valve stenosis, one with an anomalous coronary artery origin, and the remainder with anomalies of the great vessels. In none was an atrial septal defect demonstrated by hydrogen or indicator-dilution technics. A miscellaneous group included three instances of complete heart block, two hypertensive and 8 normal control subjects. The series was equally divided by sex, there being 73 male and 72 female subjects. Ages ranged from 13 to 69, with a mean of 39 years. Twelve patients were under 20 years of age and 34 were over 50 years of age; the ages of the great majority (98 patients) lay between these limits.

The ability to cross the atrial septum without needle puncture could not be correlated with the pathologic condition of the heart, the sex, or the age of the patients.

**Anatomy of the Fossa Ovalis**

The fossa ovalis is the depression in the otherwise relatively flat interatrial septum. A robust muscle, (the fasciculus of the septum) runs peripherally around the fossa to produce a raised margin, (the limbus fossa ovalis) which is more distinct above and at the sides than below. Figure 2 well demonstrates this feature and stresses the considerable depth.

### Table 1

**Incidence of Transseptal Passage Without Needle Puncture**

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Septal perforation without needle</th>
<th>Septal needle puncture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic rheumatic valvular disease</td>
<td>81</td>
<td>32</td>
</tr>
<tr>
<td>Primary myocardial disease</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Complete heart block</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Systemic hypertension</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Normal heart</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>106 (63%)</td>
<td>39</td>
</tr>
</tbody>
</table>
from the limbus to the fossa floor. The overhanging superior lip of the circumscribing
rim we have called the "limbic ledge" and it is the distinctive flicking of the catheter tip
over this ledge and down onto the fossa floor that allows recognition of the anatomic land-
mark.

Although the floor of the fossa contains cardiac muscle in variable amounts, it is pri-
marily an area of fibrous adhesion between the limbus (representing the lower edge of
the septum secundum) and the right face of the valvular foraminis ovalis (representing
the septum primum).7

Incomplete adhesion of this membranous vestige of the septum primum results in
"probe patency" of the foramen ovale, offering an explanation why these patencies are
invariably in the uppermost area of the fossa floor, tucked under the overhanging protu-
berance of the limbus. Even when no patency is left, this area is much thinner than the rest
of the fossa and may be almost transparent.

Arey,8 Gray,9 Grant,10 and Morris,11 stated that only 20 to 25 per cent of foramen ovales
remain probe patent in adult life. This is the figure derived by Patten 12 from his review of
the work of Allexieff,13 Hinze,14 and others. In all Patten reported 10 studies totaling
4,083 examinations in which 1,103 (24.6 per cent) incomplete closures were found. Some
of the individual papers, however, showed a marked variance from this mean, with in-
complete closure reported in 224 of Klob's15 500 cases (45 per cent) and 130 of Rostan
and Zahn's16 300 cases (43 per cent). Hence, the high percentage of catheterizations in
which the atrial septum could be crossed without needle puncture was initially inter-
preted as being due to the presence of patent foramen.

Anatomic confirmation appeared to come from the surgeons' description of the atrial
septa in patients who came to operation sub-
sequent to transseptal left heart catheteriza-
tion and in whom no hole in the atrial septum
apart from the foramen ovale was reported.

This initial impression was modified, how-
ever, by an autopsy on a woman who had
recently been catheterized. A separate hole
in the tissue-thin membrane of the fossa floor
was found 1 cm. from a probe patent fora-
men ovale.

It seems likely, therefore, that many pa-
tients in whom probe patency is expected
may represent those in whom the puncture of
a paper-thin membrane by slight pressure is
effected. (Since this has been appreciated,
the sensation as the membrane "gives way"
has been quite apparent.) This contention is
supported by a recent paper5 in which 68
perforations of the atrial septum without
needle puncture are reported in a series of 78
patients. The author concludes that natural
probe patency could not explain the fre-
quency of successful catheterization.

An analysis of human hearts obtained post
mortem was undertaken to confirm this point.
The Teflon catheter was easily able to per-

Figure 2

The fossa ovalis, viewed from the right atrium. The
distinct upper ledge (the limbus fossa ovalis) and the
depth of the fossa floor from the ledge can be clearly
seen. (The transverse diameter of the fossa is 2 cm.)
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forate the thin upper segment of the fossa ovalis. Aldridge⁵ made a similar study with dog hearts immediately after sacrifice and had the same findings. He further presented autopsy evidence that no greater septal damage is produced by needleless perforation.

**Limbic Ledge Identification in Cardiac Disease**

A most significant point in the technic of identifying the limbic ledge of the fossa ovalis is that its site is usually not at the junction of the lower and middle thirds of the atrial septum but a good deal higher.

In aortic valve disease, the ledge is repeatedly encountered in the upper half and occasionally in the upper third of the septum, immediately below the area in which the sensation of aortic pulsation can be appreciated through the needle.

In mitral valve disease, the limbic ledge tends to lie lower and is detected, in severe valvular disorders, in the lower third. The impression is gained that the left atrium bulges into the high right atrium and the fossa ovalis tends to be on the under surface of the bulge. This bulging may be so marked as to interfere with the free mobility of the catheter in the right atrium.

Passage of the Teflon catheter through the thin membrane of the fossa ovalis is painless. This fact has been used for confirmation of accurate placement of the catheter as, in some patients, pressure at any other position in the atrium causes dull pain, localized to the center of the chest beneath the lower sternum. It does not radiate into the arms and disappears immediately the catheter is released.

**Complications**

Only two types of complication have been encountered with this modified technic. They are not peculiar to the modification but could occur with standard transseptal methods.

In three patients the pericardial space has been entered through the posterior right atrial wall. All have had severe mitral valve disease with bulging atrial septa and poorly defined limbic ledges. In two, there was no morbidity or pain, and the situation was recognized only by the inability to withdraw blood from the catheter. In the remaining case, there was some pain and a period of mild hypotension for some hours. Withdrawal of the catheter was not followed by any change in the cardiac silhouette or a friction rub. These complications occurred early in the experience of operators who were learning this transseptal technic.

The other complication, of a temporary nature, is an occasional run of atrial contractions with the catheter at the junction of the superior vena cava and the right atrium. This ceases when the catheter is withdrawn and can be avoided when, with increasing experience, the operator can identify the limbic ledge without first advancing the transseptal catheter as high as the superior vena cava.

Aortic puncture, a leading complication of the standard method, has not occurred in this series. With the puncture pressure used and the bluntness of the transseptal catheter it is unlikely that this complication will be seen.

**Conclusion**

A technic modifying the standard Brockenbrough method of crossing the atrial septum by positively identifying an anatomic landmark in the right atrium is described in a series of 145 patients.

The ability to define the limbic ledge of the fossa ovalis and to position the transseptal catheter immediately below the ledge on the "paper thin" area of the fossa floor, has greatly enhanced the safety, the sureness, and the speed of left heart catheterization.

This procedure has enabled the perforation of the septum in two thirds of the cases without needle puncture, and the lack of damage to the septum has been confirmed.

In the 39 cases in which gentle pressure did not enable the catheter to pass through the septum, the safety of the standard needle puncture was assured by the ability to position the catheter tip accurately.

The very few complications further recom-
mend this modification of the transseptal technic of left heart catheterization.

References

William Harvey and the Scientific Revolution

Prior to the Scientific Revolution, medicine had already long been grounded on the descriptive and observational sciences, and subjects such as anatomy had become a well-developed study as early as the sixteenth century. Indeed, in 1628, William Harvey, anticipating the introduction of experiment into human biology, announced a discovery that united structure and function—the heart acts as a pump and the blood moves in continuous circulation through the body. Perhaps looking at the valves in the heart started Harvey thinking and soon he began simple experiments with the valves in his own veins. Measurement also played an important part in this discovery, for Harvey measured the capacity of the heart and found that in a single hour it pumped a much larger quantity of blood than the amount present in the whole body.—Introduction, Edward D. Churchill, M.D. Listen to Leaders in Medicine. Edited by Albert Love and James Saxon Childers. Atlanta, Tupper and Love, Inc., 1963, p. 6.
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