Arterial Complications Incident to Cannulation in Open-Heart Surgery *

With Special Reference to the Femoral Artery

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Introduction

THE AVOIDANCE of preventable mortality in open-heart surgery entails continuous and serious attention to numerous minute details in all aspects of the preoperative work-up, the operative procedure, management of extracorporeal perfusion, and the postoperative care of patients. Certain known preventable factors have been solved. Many unknown factors contributing to morbidity and mortality have yet to be described. The possible complications arising from the arteries used for the inflow catheter have not been stressed. It has been only by trial and error and retrospection that some of these difficulties in our hands have been defined.

Early in the development of extracorporeal circulation, the subclavian arteries were used for the arterial input.[4] It was believed that the subclavian arteries could be sacrificed with impunity, because of the number of patients on whom Blalock-Taussig operations had been performed without serious consequence related thereto. Close scrutiny of the literature, however, revealed that a small but definite risk existed, with gangrene of the forearm following sacrifice of the subclavian artery.[2, 5] Nevertheless, with this small calculated risk in mind, the use of the subclavian artery for the arterial inflow catheter became the vessel of choice for open-heart cases.

During 1957, two open-heart patients expired in the early postoperative period, with a clinical picture suggesting basilar artery insufficiency. The mobilization of the subclavian artery involved the incidental sacrifice of the vertebral artery on the same side. In both instances, the sacrificed vertebral artery was the main contributor to the basilar artery. This dire complication stimulated an extensive review of the literature, and a series of pathologic investigations for the incidence of anomalous vertebral-basilar artery communications.[1, 3]

From this data, it is estimated that with ligation of the left vertebral artery, basilar artery insufficiency will be produced in at least 3.1 per cent of cases; and when the right vertebral artery is ligated, basilar artery insufficiency will be produced in approximately 1.8 per cent of cases. In our series of open-cardiac cases to date, in which the subclavian artery has been used for the arterial input, the incidence of basilar artery insufficiency with fatal results was 6.0 per cent. As these anomalies are

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congenital, the incidence is obviously not affected by age. However, with advancing age, arteriosclerotic changes in one vertebral may further increase the incidence of a single vertebral artery being the main contributor to the basilar artery, thus posing an additional theoretical contraindication to the use of the subclavian artery with sacrifice of the ipsilateral vertebral artery.

After elucidation of these vertebral-basilar artery anomalies, it was believed the femoral artery should be used for the arterial inflow catheter. This route has been used routinely since that time, except in unusual circumstances.

The following two case reports serve to emphasize that the use of the femoral artery for the inflow catheter is not without risk, as well.

Case Reports

Case 1. W. M., a 45-year-old white man, had a history of long-standing rheumatic valvular heart disease. When admitted to the hospital, he demonstrated the typical physical findings and cardiac catheterization data compatible with moderate cardiac enlargement, atrial fibrillation, and aortic and mitral regurgitation and mitral stenosis (Class IV-C). The patient was operated upon by the open technic, with the utilization of our extracorporeal unit. At the time of insertion of the femoral artery catheter, it was noted that a considerable degree of arteriosclerotic plaquing was present. The catheter was inserted with some difficulty, and it was the impression of the operating surgeon (K.A.M.) that the catheter was actually in a plane between the intima and the media. It was necessary then to extend the incision by detaching the fascia from the anterior superior iliac crest. The external iliac artery was exposed retroperitoneally. With exposure of the external iliac artery, it was apparent that the catheter previously inserted had dissected a portion of the intima from the media. The iliac artery, at this point, was in severe spasm. An incision was made into the artery above the constricted area. Cannulation was effected with a No. 20 arterial cannula, but only into the artery for a distance of 4 cm. The angle of the catheter with its connectors in this space was such that approximately 2 cm. of the catheter was exposed outside the vessel. Appropriate sutures were taken to secure locally this portion of the catheter. The retrograde pulsatile flow was reasonable, but not excellent.

The operation then proceeded. During bypass, with the left atrium open, the femoral artery catheter "flipped" out of the artery. Despite rapid partial closure and clamping of the atriotomy and reinsertion of the catheter, the patient developed intractable ventricular fibrillation and could not be resuscitated after reestablishment of adequate perfusion.

Comment: The presence of arteriosclerotic plaquing in the femoral artery resulted in a localized dissection of the vessel in the usual plane of a planned thromboendarterectomy. This local complication necessitated a placement of the catheter at a higher level in the pelvis. The external iliac artery at this point tends to sway posteriorly in the hollow of the pelvis. Unfortunately, the catheter connectors routinely used were sufficiently bulky so that a segment of the catheter of necessity remained outside the vessel. Attempts were made to fix this segment of catheter by suture, so that the complication, which did in fact occur, would be avoided.

Thus, the presence of acquired peripheral arteriosclerotic disease made necessary a change in routine arterial cannulation which eventuated in a complication resulting in the death of the patient.

Case 2. F. C., a 53-year-old white man, evidenced long-standing rheumatic valvular heart disease. The patient, five years previous to his present hospital admission, had undergone a mitral commissurotomy for tight mitral stenosis. Upon this admission to the hospital, the patient revealed rather typical physical findings and laboratory data compatible with mitral stenosis and regurgitation, and minimal aortic regurgitation, with generalized cardiac enlargement (Class IV-D).

The patient was operated upon by the open technic, with the utilization of our extracorporeal unit. The exposed femoral artery revealed some posterior arteriosclerotic plaquing. Although the vessel would have taken a larger catheter, a smaller (No. 20) catheter was inserted, in order to avoid the possibility of loosening an arteriosclerotic plaque higher in the vessel. The artery was cannulated with ease, and the catheter was placed up through the common femoral artery into the external iliac artery, approximately 4 cm. proximal to the inguinal ligament. Pulsations ob-

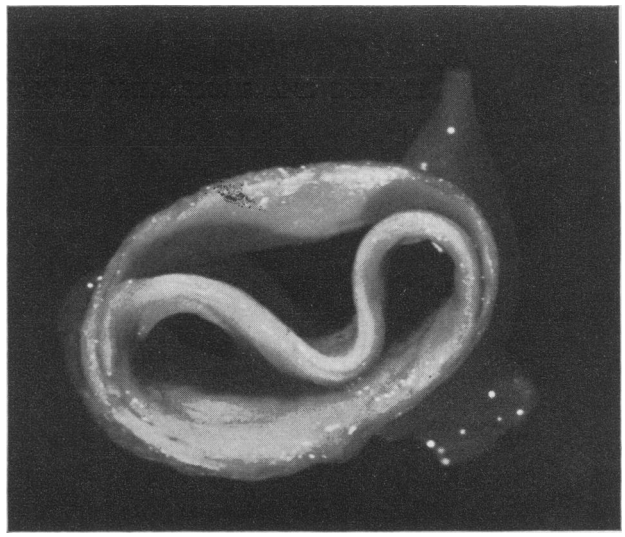

FIG. 1. Photograph of a cross section of the upper abdominal aorta removed from Case 2.

served in the clear tubing proximal to the catheter were good.

The bypass was begun, and the left atrium opened, revealing a tight mitral stenosis and multiple large atrial thrombi. Approximately 4 minutes had elapsed, when the arterial pressure in the left radial monitoring catheter suddenly dropped precipitously. The reservoir within the extracorporeal unit suddenly decreased, and the heart developed asystole. Within a few seconds following this, the pericardium suddenly filled with bright red blood, with appeared to be coming from the posterior aspect of the heart within the pericardial sac. Following a prolonged effort to control the hemorrhage, it soon became an impossible situation, and the patient was pronounced dead. On the operating table after death the diagnosis was suspected and made. At autopsy, a more detailed study revealed that a dissection plane had begun between the intima and media. This had been established in the external iliac artery immediately above the tip of the arterial catheter. The dissection progressed from the right external iliac artery up to the base of the aorta, with rupture of the outer wall of the aorta at the right coronary cusp. There was also dissection out the superior mesenteric and celiac arteries for a distance of 2 to 4 cm. The right innominate artery was dissected up to its bifurcation and down into the right subclavian artery to the axillary artery. There was also dissection up the carotid arteries to the base of the skull (Fig. 1, 2).

Comment: The presence of arteriosclerotic plaquing in the femoral artery was identified at operation. Despite this, the lumen was adequate to receive a larger catheter than the No. 20 utilized. In fact, the smaller catheter was chosen in order to avoid the possibility of loosening a plaque and creating possible retrograde embolization. After passage of the catheter, good pulsations were observed in the clear tubing proximal to the cather. In addition, prior to opening the left atrium, a stable perfusion was in evidence for three minutes prior to the catastrophe which occurred. Therefore, it appears likely that no false passage of the catheter was made upon its insertion. Either a laceration of the intima occurred at the very tip of the catheter, during its insertion, or by the motion of the tip, or the jet stream created by perfusion. In any event, a fatal retrograde dissecting aneurysm developed.

In two patients, there were two minor complications of femoral wound hematoma. Both were recognized in the operating room by the presence of a cyanotic extremity in the face of good arterial pulsations. The wounds were reopened, and the leak at the arteriotomy site controlled by an additional suture. Such complications can be prevented by accurate hemostasis and delay in wound closure until the Heparin effect has been completely re-

TABLE 1. *Arterial Inflow Complications*

	No. Subclavian Artery Inflow	Complications				No. Femoral Artery Inflow	Complications				Total No. of Patients	Complications			
		Major*		Minor**			Major*		Minor**			Major*		Minor**	
		No	%	No.	%		No.	%	No.	%		No.	%	No.	%
Congenital heart disease	33	2	6.0			56			1	1.7	89	2	2.2	1	1.1
Acquired heart disease	6					30	2	6.6	1	3.3	36	2	5.5	1	2.7
Total	39	2	5.1			86	2	2.3	2	2.3	125	4	3.2	2	1.5

* Major: Resulting in death of patient.
** Minor: Resulting in femoral wound reexploration, but not death of patient.

versed. Since we have followed this routine, we have had no further problems of wound hematoma (Table 1).

Discussion

Numerous problems which create morbidity and mortality reside in the extracorporeal circuit and the specific lesions present in each individual patient. It has become apparent, as experience has accumulated, that many of the deaths occurring early in the combined experience of many groups have been established as preventable. Undoubtedly, as more problems are defined, additional means will be found to avoid or minimize them.

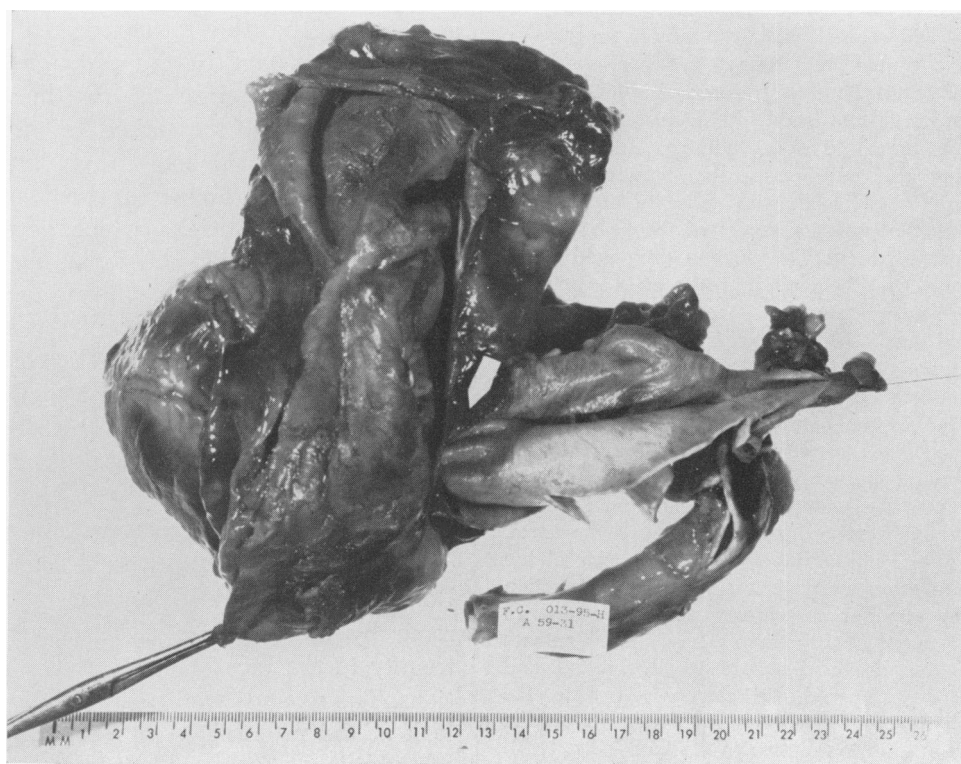

FIG. 2. Photograph of the anterior aspect of the heart and ascending, arch, and descending portions of the aorta, removed from Case 2. The lumen of the ascending aorta is not seen, but the medial dissection plane has been opened to demonstrate its extensiveness. The arrow indicates where the medial dissection plane ruptured into the pericardial sac. Note the dissection up the innominate artery.

Arterial complications have been described with the use of the subclavian and femoral arteries. It has been shown that the use of the subclavian artery for the arterial input, wherein the vertebral artery is sacrificed, carried with it a predictable mortality rate. It would appear that in patients with congenital lesions, the use of the subclavian artery should be avoided. No serious femoral artery complications have occurred in the age group involved with congenital cardiac problems. In fact, infants weighing 4 kg. have had successful perfusions via the femoral artery. Thus, it would appear that serious arterial complications can in the main be avoided by the utilization of the femoral artery for the arterial input in patients with congenital heart disease.

However, in patients with acquired cardiac disease, the routine use of the femoral artery for cannulation will create certain major problems. Many such patients are in the age group where significant arteriosclerosis is often present in the lower aorta, iliac, and femoral vessels. The dangers relate to the possibility of freeing an arteriosclerotic plaque which may become an embolus or a retrograde dissecting aneurysm. A third distinct possibility relates to the presence of a Leriche syndrome at the bifurcation, which may make retrograde perfusion an impossibility, or impair the flow to such an extent that an inadequate perfusion results.

The fact that in this series of 35 patients with acquired disease, major complications resulting in death occurred in two (5.5%) suggests that some thought be given to recommendations which may help in preventing these catastrophes. These thoughts are as follows:

1. The preoperative palpation of both right and left femoral pulsations.

2. The use of soft catheters, but ones stiff enough so that kinking will not take place.

3. The catheter tip should be cut off squarely, and the edges rounded.

4. The catheter should be placed into the iliac artery approximately 6 cm. proximal to the femoral arteriotomy.

5. The catheter itself should be secured tightly with a tape ligature around the vessel in which it is inserted, and the connections sutured securely into place to the wound edges. The catheter should also be completely within the vessel, so that the adapter is flush with the arteriotomy wound.

6. The correct size of arterial catheter for each individual artery should be used. Its insertion should not be forced in any way.

7. The use of papaverine beneath the adventitia of the artery helps to produce a local maximum dilatation.

8. Following the insertion of the catheter, it should be established routinely that a good pulsation is present in the clear tubing proximal to the arterial catheter.

Item 1 may help the surgeon in deciding which of the femoral arteries has the stronger pulsation, and therefore the vessel with the larger luminal communication with the proximal aorta. Item 8 gives information concerning the proper placement of the catheter in the arterial lumen, and also gives an estimate of the inertia in the system. Obviously, both of these maneuvers are gross and qualitative. In order to avoid situations wherein there is a reduced arterial channel above the femoral artery, a direct measurement of the femoral arterial pressure would appear to have merit. While this has not been used for this particular purpose, in patients being operated upon for peripheral vascular insufficiency, partial and complete blocks proximal to the femoral artery have always been reflected in a markedly lowered femoral arterial pressure, when compared to the brachial pressure, measured by an ordinary blood pressure cuff. Thus, serious obstructions to retrograde flow may be uncovered.

It would appear that in the patients with acquired cardiac disease, complications

secondary to femoral cannulation can be minimized by careful attention to some of these details. Undoubtedly, there will be the rare situation where the femoral artery cannot be used for the arterial inflow. In this event, the subclavian would seem to be the vessel of choice; however, if it were anticipated preoperatively, a retrograde angiogram defining the pattern of the vertebral arteries would be of great value, and care taken to avoid the sacrifice of the dominant vertebral artery, so that retrograde flow via the vertebral might still be possible.

Summary

Over the last three years, 125 patients have been operated upon for intracardiac defects, aided by extracorporeal perfusion. During this period, four patients (3.2%) have died secondary to major arterial complications from the inflow arterial catheter. Two additional patients (1.6%) suffered minor complications. Thus, the over-all incidence of arterial complications has been 4.8 per cent.

Two patients with congenital heart disease (6.0%) died with basilar artery insufficiency, secondary to the use of the subclavian artery, with sacrifice of the ipsilateral vertebral artery. There have been no deaths due to arterial complications in the patients with congenital heart disease in which the femoral artery has been used for the inflow catheter, even in infants weighing 4 kg. Thus, the femoral artery appears to be the vessel of choice in this age group.

The remaining two patients, both over 45 years of age, and with multivalvular acquired heart disease, died secondary to complications due to arteriosclerotic changes in the femoral and iliac arteries which were used for the inflow catheter. Thus, in the group of patients with acquired heart disease, there was an incidence of arterial complications, from the inflow catheter, of 6.6 per cent.

Recommendations for preventing or minimizing these complications have been made.

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