Improved Limb Salvage After Arterial Embolectomy

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Between January 1965 and August 1977, 122 patients with 135 arterial emboli were treated on the Peripheral Vascular Service at the Ohio State University Hospital. The heart was the source of the embolus in 94 patients (77%), one-third of whom had experienced a myocardial infarct. Thirteen patients died after the operation, which in 102 patients (84%) consisted of embolectomy only, making the hospital mortality 10.6%. Fourteen patients (11.5%) required subsequent amputations during the same hospitalization or on a later admission. The corrected limb salvage rate of 80.9% was unrelated to the length of delay in presentation. Although only 70 patients (57.4%) had palpable distal pulses following operation, 89 (73%) had a functional limb at the time of discharge or on later follow-up. An aggressive approach to the patient with an arterial embolus, regardless of the duration of symptoms, is urged. Embolectomy under local anesthesia is advocated in all cases after prompt correction of fluid and electrolyte imbalance and stabilization of the underlying cardiac disorder, except in patients with frank gangrene and irreversible rigor. In the absence of distal pulses or obvious revascularization, an intraoperative arteriogram is mandatory.

OWING TO THE INCREASING longevity of our population, peripheral arterial embolism occurs with increasing frequency and requires surgical intervention. Embolectomy remains the preferred treatment for most symptomatic arterial emboli. Labey[12] performed the first successful embolectomy in 1911 in a patient with embolic occlusion of the femoral artery. After disappointing results from the use of corkscrew wires,[19] retrograde flushing,[11] and suction catheters,[4] a substantial reduction in mortality and morbidity followed the introduction of the balloon catheter by Fogarty and associates in 1963.[5] Despite stabilization of the mortality rate, owing to increasingly sophisticated management of the underlying cardiac problem, the reported amputation rate still varies from 12% to 22%,[7-10,13,14,17] and further improvement in limb salvage is desirable.

Experience in treating 122 patients with arterial emboli is reviewed, and mortality and amputation rates after embolectomy analyzed. The functional status of the extremity following embolectomy and the need for the preoperative administration of heparin to increase limb salvage are discussed.

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Patient Material

This review comprises 122 consecutive patients with 135 arterial emboli who were cared for by the Peripheral Vascular Service at The Ohio State University Hospitals between January 1, 1965 and August 30, 1977. Arterial emboli related to cardiac catheterization or arterial reconstruction were excluded. Patient symptoms, signs, pre- and postoperative anticoagulation status were all recorded, and delay in treatment (embolectomy) was correlated with limb salvage. The functional status of the extremity and the need for further arterial reconstruction were assessed at discharge and on follow-up.

Patients' ages ranged from 27 to 96 years, and the majority (60%) were over 60 years of age. There were 64 women and 58 men.

Source and Location

The heart was the source of the embolus in 94 patients (77%) (Table 1). The majority of these patients had associated atrial fibrillation, usually with pre-existing arteriosclerotic heart disease. Rheumatic heart disease with atrial fibrillation was the etiology of the emboli in 17 patients. Thirty-one patients sustained an arterial embolus following documented myocardial infarction, over two-thirds occurring within three weeks of the infarct (Fig. 1). No source for an embolus could be identified in 25 patients (20.5%), despite an active search for underlying cardiac disease. A history of a previous arterial embolus was elicited in 23 patients, in 19 of whom the episode was remote (more than 21 days).

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TABLE 1. *Source of Arterial Emboli*

Type			#	%
I	Cardiac		94	77
	A. Myocardial infarction	(31)		
	recent < 3 wks	21		
	remote > 3 wks	10		
	B. Atrial fibrillation	(53)		
	with arteriosclerosis	36		
	without arteriosclerosis	17		
	C. Cardiomyopathy	(6)		
	D. Others	(4)		
II	Proximal aneurysm		3	2.5
III	Unknown etiology		25	20.5

Sites of arterial occlusion by emboli are listed in Table 2. The most frequent location was in the femoropopliteal region (48%). The proportion of patients with emboli lodged in the femoropopliteal region remained the same during the last four years of the study, which is in contrast to a decline in the percentage of patients with emboli in the aortoiliac area ($p < 0.01$).

Symptoms

Sudden onset of pain was universal (100%) in patients with peripheral arterial emboli (excluding visceral and cerebral emboli). Numbness (84%) and paralysis of the extremity (27%) were less common (Table 3). Coolness, pallor, and pulse loss were present on physical examination in most instances, whereas cyanosis was usually evident in patients who presented more than 24 hours after the onset of pain.

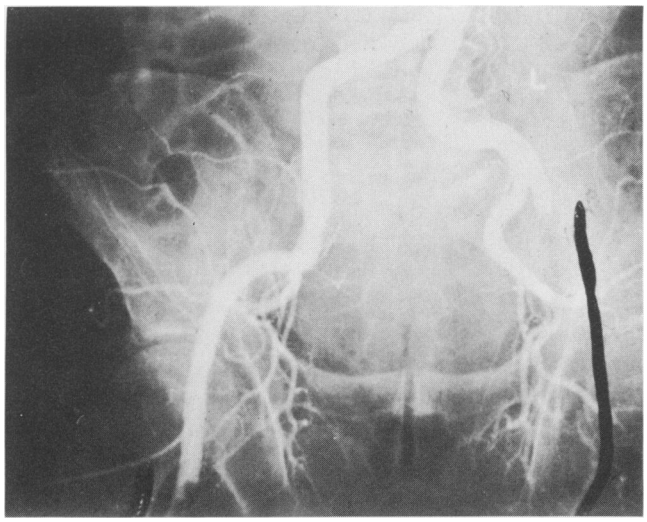

FIG. 1. Transfemoral aortogram with operative specimen, showing simultaneous right common femoral and left external iliac artery embolization in a patient following aute myocardial infarction.

TABLE 2. *Location of Arterial Embolus*

Source	1965–73	1973–77	Total	%
Aortoiliac	36	7	43	35
Femoropopliteal	33	26	59	48
Axillary-subclavian	3	1	4	3
Distal arm	7	6	13	11
Carotid	1	0	1	1
Renal	1	0	1	1
G.I. tract	1	0	1	1
	82	40	122	100

Preoperative and Postoperative Management

Preoperative angiography was obtained in only one-third of the patients, since in most cases, the presentation was clear-cut (Table 4). Local anesthesia was used in 92 patients (75%), while a general or spinal anesthetic was required in 29 patients (25%). Intravenous heparin was administered to 40 patients (33%) preoperatively (Table 5). The technique of embolectomy consisted of exposure of the common femoral artery at the groin or the brachial in the mid-upper arm via longitudinal incisions. A small transverse arteriotomy was made after proximal and distal control of the artery had been obtained. Repeated passes with a Fogarty catheter were made (sizes #2, #3, in the arm and #3, #4 in the lower extremity) distally until at least two successive attempts at clot retrieval were negative. Following this, heparinized saline was injected into the distal vessel, which was then clamped. The proximal artery was then dealt with in a similar manner, and the arteriotomy was then closed with running, fine monofilament sutures.

Following operation, arteriography was performed in 23 patients (19%), usually on the operating table. The extent of the operative procedure varied from simple embolectomy (84%) to a simultaneous laparotomy in 5 patients (Table 6). Concomitant fasciotomy (without fibulectomy) was performed in only 12 instances (9.8%), predictably in patients who presented 48 hours or more after the onset of symptoms and demonstrated the presence of a compartment syndrome.

Postoperative anticoagulation therapy with intra-

TABLE 3. *Signs and Symptoms (119 Patients)*

	Number	%
Pain	119	100
Cool extremity	119	100
pulse loss	118	99
Pallor	103	92
Cyanosis	7	
Numbness	100	84
Paralysis	32	27

TABLE 4. *Pre- and Postoperative Arteriography*

	Pre-operative		Post-operative	
	#	%	#	%
Radiology suite	42	35	2	19
Operating room	1		21	
No arteriogram	79	65	99	81

TABLE 6. *Surgical Procedure Required*

Procedure	Patients	%
Embolectomy	102	84
Embolectomy & Fasciotomy	12	9.8
Embolectomy & Laparotomy	5	4
Reconstruction	2	2
No Surgery	1	—

venous heparin was given to 92 patients (75%) for 5–7 days, after which oral coumadin was given, depending on the source of the embolus and the clinical situation.

Results

Thirteen patients died during or after the embolectomy, yielding a hospital mortality of 10.6%. Over half the total number of deaths resulted from myocardial infarction or drug-resistant arrhythmias. Thirty-six complications occurred postoperatively (Table 7). Nearly one-half of these were wound complications, most frequently groin or arm hematomas. Five patients were reoperated on for persistent limb ischemia, and one required patch-grafting of the arteriotomy site. No complications associated with the use of the Fogarty catheter, *i.e.*, perforation or intimal disruption of the artery, were described in the operative notes.

Amputations were necessary in 14 patients (11.5%) during the same hospitalization or on a subsequent admission. Eleven of these were above-knee amputations. Of the 43 patients who were operated on within 12 hours of the onset of symptoms, 4 (10%) had amputation. Seven of 76 patients (11%) who were operated on more than 12 hours after onset had amputations ($p > 0.05$) (Table 8). Overall, limb salvage was 89.5% in the immediate survivors, excluding the single nonoperative case. However, if a total of 9 patients who died before functional evaluation was completed, those in whom the limb status was unclear, and patients with visceral and carotid emboli are excluded, a corrected limb salvage rate of 80.9% (99 patients) was obtained. More important, 89 patients (73%) had a functional extremity at the time of discharge or later follow-up, although pulses were palpable postoperatively in only 70 patients (57.4%, Table 9). Three patients later underwent elective revascularization of the extremity, three had open heart surgery, two had revisions of their amputations, and a single patient required intestinal revascularization on late follow-up.

TABLE 5. *Pre- and Postoperative Anticoagulation*

	Pre-operative		Post-operative	
	#	%	#	%
No heparin	82	67	29	24
Heparin/coumadin	40	33	92	75
Died/intraoperatively	—	—	1	1

Discussion

The heart is the most common source of peripheral arterial emboli, with the reported prevalence varying from 75 to 87%.[9,10,17] Arteriosclerotic heart disease has replaced rheumatic heart disease as the common denominator, owing to the increasing longevity of the general population.[9,10] Chronic atrial fibrillation with and without atherosclerotic coronary artery occlusive disease was present in nearly half of our patients and has traditionally been the hallmark of arterial embolism. However, a significant number of patients did not demonstrate fibrillation but had evidence of recent or remote myocardial infarction. Peripheral embolism has been said to occur in only about 1% of patients with acute myocardial infarction,[15] but the relatively com-

TABLE 7. *Mortality and Morbidity in Patients with Arterial Emboli*

		Pts.	Per cent
Mortality		13	10.6
Morbidity		36	
Cardiac–7			
myocardial infarct	(3)		
arrhytmias	(2)		
cardiac failure	(2)		
Renal–4			
renal failure	(3)		
urinary infection	(1)		
Pulmonary–4			
pulmonary embolus	(2)		
pulmonary edema	(1)		
pneumonia	(1)		
Wound–15			
hematoma	(5)		
infection	(4)		
dehiscence	(3)		
bleeding	(1)		
lymphocele	(1)		
leg edema	(1)		
Reoperations–5			4
Cerebrovascular accident–1			

TABLE 8. *Time Interval to Surgery vs. Limb Salvage (119 Patients)**

Time Interval (Hrs)	Patients		%	Limb Salvage #	Limb Salvage %
0–6	28	43	36	39	90
7–12	15				
13–24	30	76	64	69	89
25–48	22				
48	24				

* Excluded are three patients (nonoperated patient, carotid and renal embolus).

mon occurrence of the latter lends considerable numerical significance to the problem of arterial embolism. In addition, mortality appears to be higher in these patients. In a recently reported series of 31 patients[18] who had arterial emboli following a myocardial infarct, the mortality was 19%, exceeding the overall mortality of emboli from all causes.

Preoperative Management

Preoperative angiography was performed in 35% of our patients for the following reasons: a questionable diagnosis, to determine the extent of occlusion and the presence of associated distal occlusive disease. In most cases the diagnosis is secure on clinical grounds alone, however angiograms are often necessary for confirmation. Routine administration of intravenous heparin has usually been recommended as soon as the diagnosis is made, to prevent further propagation of clot, especially when embolectomy is delayed.[9,17] Although this is a reasonable assumption, no prospective study demonstrating the efficacy of preoperative heparin administration is available, and Freund et al.[7]

TABLE 9. *Results of Embolectomy*

Limb Status	Patients	%	
Limb salvage, functional, pulse present	70	57.4	80.9%
Limb salvage, functional, pulse absent	19	15.5	
Limb salvage, poor function, pulse absent	10	8	
Amputation required	14	11.5	
above knee 11			
below knee 2			
fore-arm 1			
Miscellaneous (died before functional evaluation, functional status unclear, carotid visceral emboli etc.)	9	8	

TABLE 10. *Recent Literature Review of Results After Arterial Embolectomy*

Authors	Year	Pts.	Amputation	Mortality
Fogarty	1967	91	4%	15%
Cranley	1970	246	5	24
Levy	1970	125	14	26
Thompson	1970	163	17	14
Greep	1973	110	12	19
MacGowan	1973	174	13	27
Freund	1974	85	20	41
Green	1975	149	14.5	24
Hight	1976	124	22	30
Authors	1977	122	11.5	10.6

noted no difference in the limb salvage rate in patients receiving preoperative heparin and those undergoing embolectomy without it. With only 33% of our patients receiving heparin preoperatively, the amputation rate in our series compares favorably with that in others.[2,3]

Some delay in embolectomy is unavoidable for treatment of associated atrial fibrillation or congestive heart failure and for correction of accompanying electrolyte imbalance. The operative technique of embolectomy is well standardized, and the end-point is return of pulses or marked improvement in color and temperature of the extremity. A quantitative estimate of the back-bleeding from the arteriotomy site is unreliable as proof of distal patency. Very frequently, small amounts of soft discontinuous clot can be extracted by repeated passage of the Fogarty catheter after what appears to be excellent back-flow. Intraoperative and postoperative arteriograms were obtained in 19% of our patients, usually when restoration of distal pulses or return of color and more normal temperature to the extremity was in question. Unsuspected technical errors and additional thromboemboli have been detected by routine intraoperative angiograms in up to 23% of patients.[16] Postoperatively, a diligent search for the source of the arterial embolus is made, and a correctable lesion is surgically treated, *i.e.* heart valve replacement, resection of proximal aneurysm.

Anticoagulation after embolectomy remains controversial. Green et al.[9] reported an in-hospital embolic recurrence rate of 7.5% for heparinized patients versus 31.2% for nonheparinized patients. However, Barber et al.[1] and Thompson et al.[18] have documented frequent embolization in patients with myocardial infarction already being treated with heparin. Postoperative anticoagulation therapy was used in 75% of our patients, mainly those with chronic atrial fibrillation and in those instances where the source of the embolus was in question. Again, no difference in limb salvage has been noted in patients receiving postoperative anticoagulants and those who did not.[7]

Mortality and Limb Salvage

The reported mortality rate after arterial embolectomy has varied from 14 to 41%.[3,6–10,13,14,17] Predictably, the majority of deaths in the preoperative period are due to cardiac causes. Considering the generalized arteriosclerosis almost always present in these patients along with serious cardiac problems, the high death rate is not surprising. Delay in presentation has been regarded as an important factor contributing to a high mortality rate. However, with 64% of patients in this series presenting more than 12 hours after the onset of symptoms and about 40% after 24 hours, the mortality rate of 10.6% was relatively low. An important factor in the improvement in survival rate was an agressive approach consisting of rapid correction of fluid and electrolyte disturbances and prompt treatment of cardiac arrhythmias, followed by embolectomy under local anesthesia. Almost all peripheral arterial emboli can be extracted under local anesthesia, except in unusual circumstances when general anesthetics are required in patients with visceral emboli and in good-risk patients who will need additional reconstructive procedures.

Although the amputation rate has declined since the introduction of the Fogarty catheter, the reported amputation rate still varies from 12 to 22% (Table 10).[7–10,13,14,17] Early operation after the onset of symptoms has generally been equated with increased limb salvage.[9,17] In our opinion, the time lapse between embolization and extraction of the emboli should not be a criterion of operability, and this is supported by our overall limb salvage rate of 89.5%. Limb salvage was essentially the same whether patients underwent embolectomy later than or within 12 hours of the onset of symptoms. The likely explanation is that a limb which remains viable for three to four days after embolization has excellent collateral formation and little or no thrombosis distal to the embolus. Hence, in the absence of frank gangrene or well-established rigor, embolectomy should be performed, regardless of the duration of symptoms.

Fasciotomy after arterial embolectomy, concomitantly or in the postoperative period, was performed in about 10% of patients in this series. Hypoesthesia in the first interdigital cleft is often an early sign of an anterior compartment syndrome and is reportedly present in 72% of patients.[2] In patients with severe and prolonged ischemia preoperatively, the hyperemic response to revascularization may result in tremendous swelling, and early fasciotomy for the compartment syndrome in this instance may prevent considerable future disability.

Limb Function

The ultimate goal of embolectomy is to ensure a useful and functional extremity. The presence of distal pulses after extraction of the embolus is certainly desirable, but their absence does not in any way signify a poor result from a functional standpoint. Although only 57% of our patients had distal pulses following embolectomy, 73% had a functional extremity. This may be a reflection of the absence of preexisting arterial occlusive disease. A small number of patients may, however, require further revascularization for relief of claudication.

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