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Original Studies

Peripheral Transluminal Angioplasty of the Subclavian and Innominate Arteries Utilizing the Brachial Approach: Acute Outcome and Follow-Up

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Percutaneous transluminal angioplasty (PTA) of the subclavian and innominate arteries was performed in 27 patients at 33 sites (30 subclavian, 3 innominate). All procedures were successful angiographically and clinically and were without complication. The ipsilateral arm was utilized in all cases. Indications for the procedure included claudication (ten patients), neurological symptoms (seven patients), to gain vascular access for other interventions (eight patients), and scheduled coronary bypass surgery with internal mammary utilization (two patients). There were 22 stenoses and 11 occlusions. Thrombi was retrogradely recovered through the arteriotomy site in three patients with vessel occlusions. No early or late episode of neurological deficit was seen. Follow-up was obtained in 22 patients (82%) at a mean time of 28 months (range, 2–73 months). The cumulative patency rate was 95%. The three restenosed sites were treated with successful repeat PTA. Angioplasty of stenotic or occluded subclavian or innominate arteries should be the procedure of choice in symptomatic patients.

Key words: subclavian angioplasty, brachiocephalic angioplasty

INTRODUCTION

Percutaneous transluminal angioplasty (PTA) has been reluctantly utilized in the brachiocephalic vessels, especially the subclavian and innominate vessels [1–12], because of the fear of embolic debris. This communication details our attempted angioplasty results in 33 subclavian or innominate lesions (22 stenoses and 11 occlusions), the technique used, the complications encountered, and patient follow-up.

MATERIALS AND METHODS

Patient Selection

Patients who underwent PTA of a subclavian or innominate lesion were chosen to be included in this study because they presented with symptoms of arm claudication or neurologic symptoms, because of the planned use of the ipsilateral mammary artery as a coronary bypass conduit when the lesion lay proximal to the mammary artery origin, or because there was need for vascular access in order to perform coronary or other peripheral angioplasty via the brachial approach (see Table I). No patient was refused angioplasty because of angiographic lesion appearance or clinical status.

Technique

An ipsilateral antecubital fossa incision was performed. The brachial artery was identified and isolated. (The brachial approach was utilized in all occluded subclavian or innominate occlusions to obviate the potential problem of distal embolization into the forearm and hand.) An arteriotomy was performed, and heparin (3,000 units) was administered into the distal segment of the artery. An 8 French multipurpose catheter over an 0.035 inch Wholey wire (ACS, Inc., Mountain View, CA) was introduced. The distal (i.e., brachial) pressure was recorded. Angiography was performed by hand injection of 8 to 10 cc of nonionic contrast (Isovue 300, Squibb, New Brunswick, NJ). The lesion was crossed using an 0.035 inch guidewire and, occasionally, redirecting the guidewire's path with a right 8 French Judkins catheter. The proximal (aortic) pressure was recorded. Additional heparin (7,000 units) was given. A

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TABLE I. Subclavian Artery PTA

Patients (n = 27)
Male, n = 7 (26)
Female, n = 20 (74)
Age (years)
Mean, 60 ± 9.2
Range, 43–72
Indications
Arm claudication and weakness, n = 10 (37)
Subclavian steal syndrome, n = 7 (26)
Vascular access to perform PTCA/PTA, n = 8 (30)
To enable use of internal mammary artery as coronary graft, n = 2 (7)
Lesion sites (n = 33)
Left subclavian artery, n = 23 (70)
Right subclavian artery, n = 7 (21)
Right innominate artery, n = 3 (9)

Values in parentheses are percentages.

TABLE II. Associated Conditions in Patients Undergoing Subclavian Artery PTA

Condition	No. (%)
Coronary artery disease	22 (81)
Peripheral artery disease	15 (56)
S/P carotid endarterectomy	10 (30)
Neurological symptoms	3 (11)
Hypertension	9 (33)
Renal artery stenosis	5 (19)
Abdominal aortic aneurysm	2 (7)
Diabetes mellitus	1 (3)

0.035 inch exchange wire (260 cm in length) was placed into the aorta. A 6 mm balloon, 4 cm in length (PE-plus, USCI, Billerica, MA) was passed to and situated across the lesion. The balloon was inflated (4–8 atm) for 60–90 sec until there was full dilation and loss of balloon waisting, usually within 60 sec. The dilation catheter was then exchanged for an angiographic catheter. Angiography was performed by hand injection. A pressure pullback was performed. The catheter was removed. The artery was permitted to bleed until excellent flow was observed. If good flow was not apparent, then a Fogarty catheter was utilized to remove any thrombus or debris. The artery was then closed using fine suture material. The procedure was considered successful if there was ≤40% residual stenosis and a mean gradient of ≤10 mm Hg. Patients were discharged within 24 hr. The only angioplasty-related discharge medication was aspirin (325 mg per day).

Patient follow-up information was obtained from office visits and direct patient and/or attending physician telephone contact. Postangioplasty angiography was assessed by the cardiovascular radiologist who reread the angiograms, was not aware of the clinical circumstances, and had not participated in the procedure.

TABLE III. Angioplasty Data*

	Pre-PTA	Post-PTA	*P* value
Lesion severity (% diameter stenosis)	87 + 14	20 + 17	0.001
Stenosis	79 ± 11	21 ± 18	0.001
Occlusion	100	17 ± 15	0.001
Gradients (mm Hg)			
Peak gradient	54 ± 26	13 ± 9	0.001
Mean gradient	27 ± 16	4 ± 3	0.001
Lesion success	33/33 (100)		
Stenosis	22/22 (100)		
Occlusion	11/11 (100)		
No. of lesions dilated	(n = 33)		
Unilateral single lesion	24		
Unilateral segmental			
Subclavian and innominate	2		
Bilateral lesions	4		
Restenosis of bilateral lesion	2		
Restenosis of unilateral lesion	1		

*Brachial approach; n = 27 patients. Values in parentheses are percentages.

Statistical Analysis

All values are expressed as mean ± S.D. The t test for paired samples was utilized. A P value of <0.05 was considered statistically significant.

RESULTS

Twenty-seven patients (Table I) underwent PTA of 33 lesions: right subclavian artery, 7; left subclavian artery, 23; right innominate artery, 3. Thirty-two lesions were proximal to the vertebral artery origin. In two cases, a concomitant stenosis of the ipsilateral vertebral artery was dilated.

The indications for the procedure were the presenting symptoms of arm weakness and claudication in ten patients; neurological symptoms of dizziness, vertigo, and diplopia in seven; vascular access in order to perform PTA or percutaneous transluminal coronary angioplasty via the brachial approach in eight; and two patients were scheduled to have coronary bypass using the ipsilateral internal mammary artery. All the patients had a diagnostic arch aortogram prior to the procedure. In three cases, a significant stenosis was dilated at the time of a planned procedure on another artery. Patient characteristics are delineated in Table II.

All 11 occlusions (Fig. 1) and 22 stenoses (Figs. 2, 3) were successfully dilated (Table III). The mean percent stenosis decreased from 87 ± 14% to 20 ± 17%, $P <$ 0.001. The mean gradient decreased from 27 ± 16 mm Hg to 4 ± 3 mm Hg, $P < 0.001$. The mean increase in the brachial systolic blood pressure was 87 mm Hg.

There were no instances of distal embolization or abrupt occlusion of the subclavian artery. Organized thrombus was removed by Fogarty catheterization in two

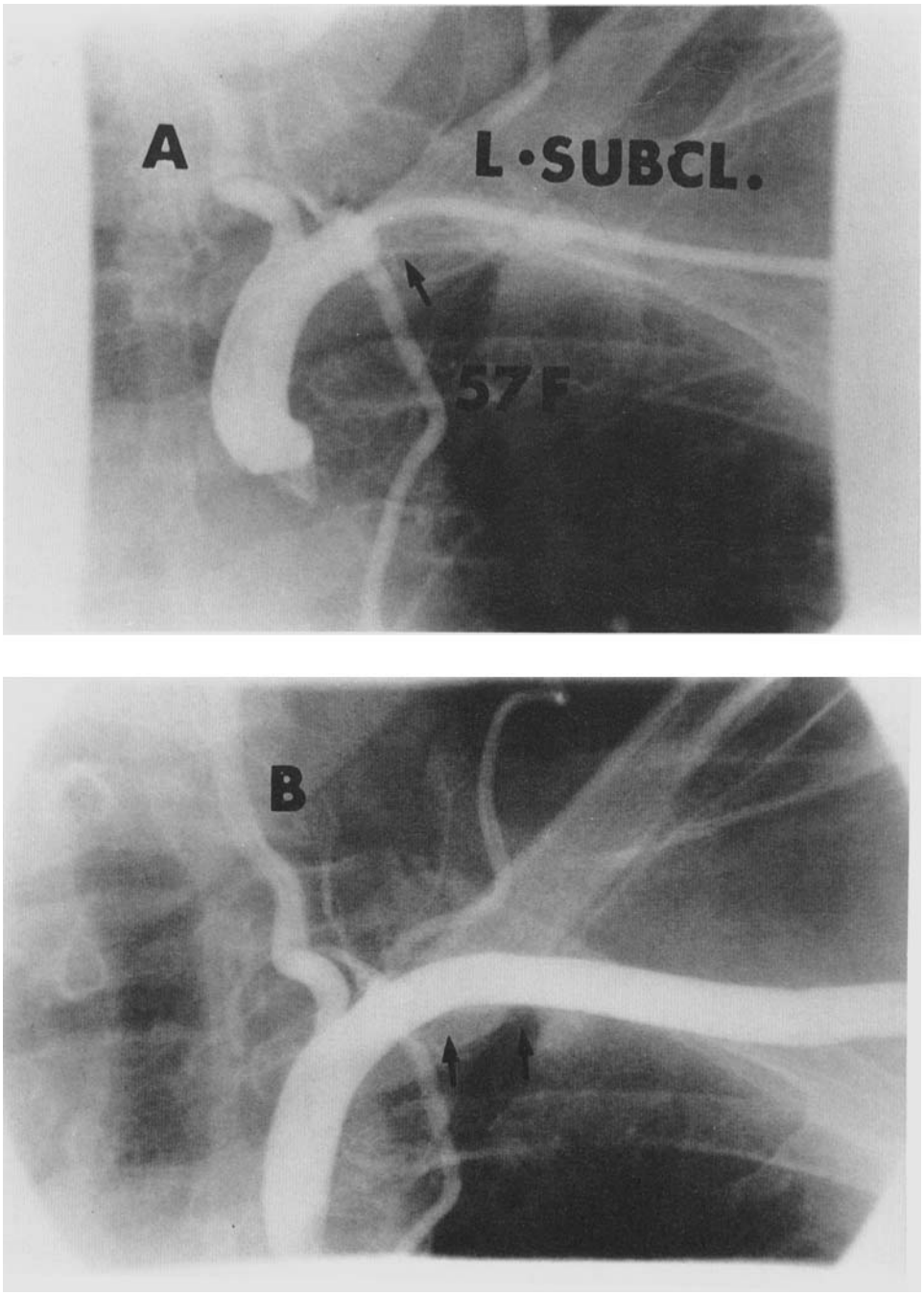

Fig. 1. A: Occluded left subclavian artery (L. SUBCL.) with patent internal mammary and vertebral branches (arrow) at the level of the occlusion. A 0.035 inch guidewire was used. B: After successful angioplasty, complete reconstitution (arrows).

patients before arterial repair (Fig. 4). An organized thrombus in one patient was spontaneously expelled from the arteriotomy during reestablishment of flow. All episodes of thrombus removal occurred after PTA of an occluded vessel. No patient suffered any neurological insult. Two patients required a surgical repair of the brachial artery because of brachial (in situ) thrombosis that occurred within 12 hr of leaving the laboratory.

Follow-up data were obtained for 22 patients (82%; Table IV). The mean follow-up time was 28 months (range, 2–73 months). The cumulative patency rate was 95%. Two patients experienced symptomatic restenosis.

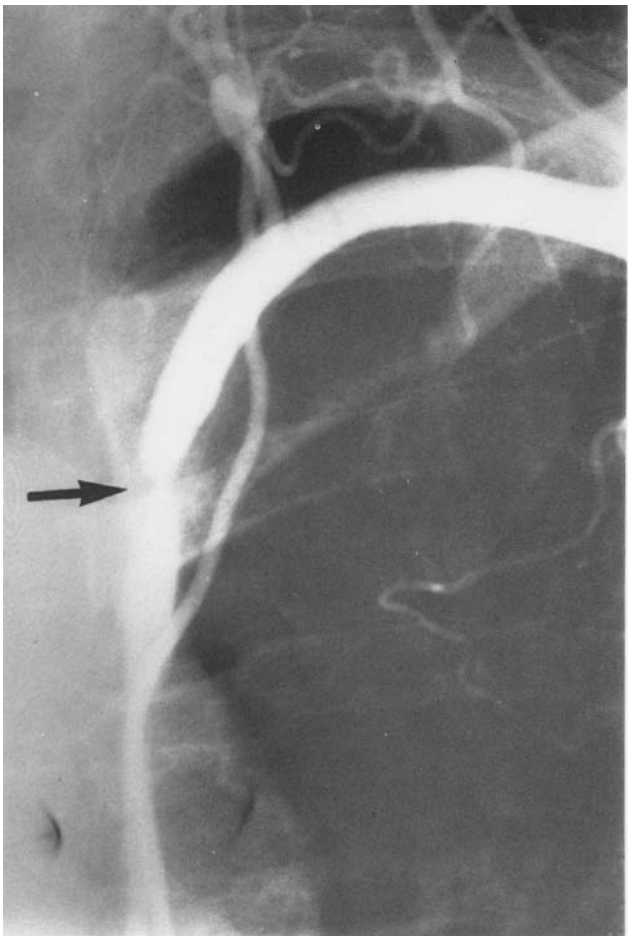

Fig. 2. An 80% stenosis of the left subclavian artery (arrow).

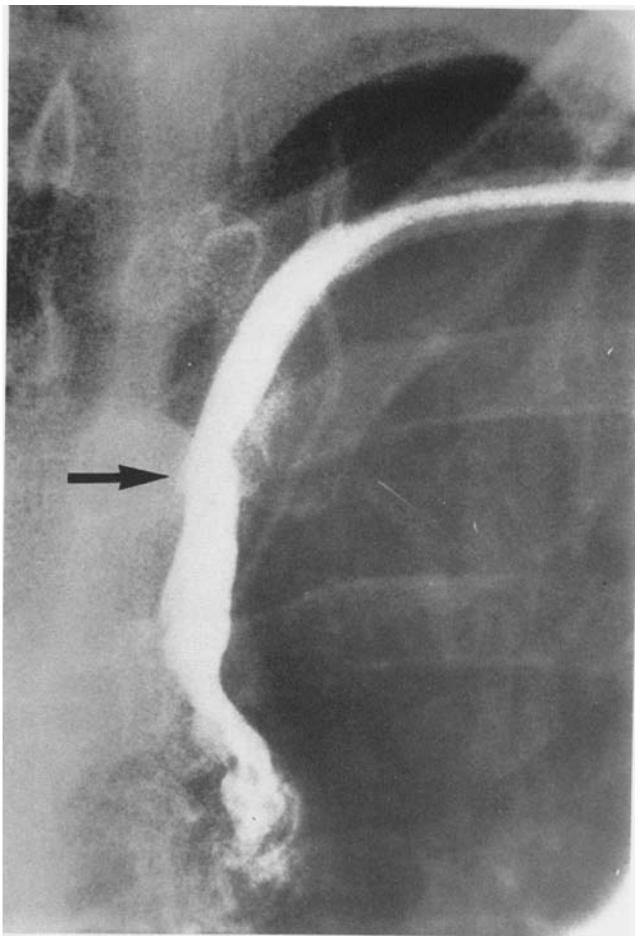

Fig. 3. Successful balloon angioplasty of the stenosis (arrow).

The first patient had recurrent bilateral arm claudication 37 months after the initial PTA, with angiographic documentation of a right subclavian restenosis of 75% and a left subclavian artery restenosis of 95%. Both lesions were successfully redilated; the patient remained asymptomatic at the 36 month follow-up. The second patient experienced recurrent arm weakness and loss of the radial pulse 6 months after the first PTA; the restenosed subclavian artery was redilated with restoration of pulse. The patient remains asymptomatic and had a good radial pulse at 61 months follow-up. There were no deaths or clinically significant complications.

The follow-up data (Table IV) were obtained from office visit records for 10 patients and telephone contact for 12 patients. Post-PTA angiography was obtained in five asymptomatic patients showing no restenosis. Nineteen patients (86%) were clinically asymptomatic, two patients were improved, and one patient was still symptomatic. Ninety-two percent of those contacted by telephone stated that they had a palpable radial pulse, which had been confirmed by their attending physician.

TABLE IV. Follow-Up of 22 Patients After Subclavian PTA

Mean time, 28 ± 21 months; Range, 2–73 months	
Status	
Asymptomatic, n = 19 (89)	
Improved, n = 2 (9)	
No change, n = 1 (4)	
Clinical restenosis, n = 2/22 (10)	
Follow-up, No. of radial pulses present (No./No. limbs dilated) 25/28 (89)	

DISCUSSION

Conventional treatment for subclavian artery stenoses or occlusions has been either medical management or surgical intervention [13–15]. The complications associated with the corrective surgical repairs of intrathoracic subclavian endarterectomy or aortosubclavian bypass have not been negligible (23%) [13], including an associated mortality of up to 8% [15]. While the extrathoracic surgical procedures (carotid subclavian transposition, subclavian–subclavian bypass, or carotid sub-

TABLE V. Cases of Subclavian and Innominate PTA in the Literature

Author References	Approach Brachial	Approach Femoral	No. of patients	No. of lesions/ occlusions	Immediate success rate (%)	Long-term clinical patency (%)	Mean F/U (months)
Wilms et al. [1]	1	21	22	23/0	91	86	25
Motarjeme et al. [2]	7	0	7	7/0	71	—	—
Vitek et al. [3]	1	14	15	15/0	100	—	—
Damuth et al. [4]	0	9	9	9/0	100	100	13
Kachel et al. [5]	—	—	17	17/1	100	—	—
Novelline [6]	—	1	1	1/0	100	—	—
Kobinia and Bergmann [7]	1	—	1	1/0	100	—	—
Gordon et al. [8]	3	5	7	8/0	63	100	20
Burke et al. [9]	15	16	27	30/2	89	71	37
Bachman and Kim [10]	—	1	1	1/0	100	—	—
Bean et al. [12]	3	3	3	3/0	100	—	—
Fields and Lemak [14]	1	—	1	1/0	—	—	—
Ringelstein and Zeumer [16]	2	10	12	12/2	75	—	—
Erbstein et al. [17]	6	18	24	22/2	88	83	18
Present study	27	—	27	33/11	100	92	18
Total	67	98	174	183/18	84%	90%	24.6

Fig. 4. Thrombotic debris extracted from axillary and brachial arteries after successful angioplasty of a totally occluded subclavian artery. No distal embolization occurred.

clavian bypass) have an associated lower mortality (5%), they nevertheless have a 15% to 25% complication rate [13–15], complications including stroke, neck lymph fistula, phrenic nerve palsy, and Horner syndrome. Symptomatic relief was obtained in approximately 75% of surgical patients [14], which is in contrast to the 95% of patients within our study.

PTA of subclavian artery lesions has been shown to be technically feasible by individual case reports as well as by published series (Table V). Therefore, PTA of subclavian or innominate artery stenosis has consistently and repeatedly been shown to be a safe and efficacious therapy. Remarkably, only one case has been reported of embolization to the vertebral artery resulting in a neurologic deficit [2].

The small incidence of neurologic complications occurring following subclavian PTA may be related to the direction of flow within the vertebral artery [16]. A severely stenotic or occluded subclavian artery produces a subclavian steal (clinically apparent or not) in which there is reversal of vertebral artery blood flow. The flow direction within the ipsilateral vertebral artery does not immediately change after subclavian angioplasty, but only gradually changes over several minutes. Thus any embolic material would migrate down the brachial artery and not into the vertebral artery. The distal embolization of debris occurred down the brachial artery in 3/11 occluded vessels (27%) and in no stenotic vessels. Thus, although the brachial and femoral approaches can both be successfully utilized in stenoses (where emboli is rare), the brachial approach may be superior in occluded vessels since the debris can be removed through the arteriotomy site. In either case, the percutaneous axillary approach is undesirable because of its high complication rate, the administration of heparin, and the inability to permit retrieval of debris.

Clearly, the excellent angiographic success in both

stenoses and occlusions, the minimal incidence of complications, and the 95% long-term vessel patency were gratifying. In addition, the two patients with restenosis were successfully redilated without incident.

The long-term symptomatic improvement could not be correlated with the lesion severity or lesion length, since all patients followed up did well. A symptomatic lesion recurrence occurred in 3/30 lesions dilated (10%) and in 2/22 patients (10%). No angiographic follow-up data were systematically obtained in patients who were asymptomatic, had no significant (<15 mm Hg) systolic pressure differences between arms, and had a palpable radial pulse. All 11 patients with successfully dilated, occluded subclavian arteries remained asymptomatic at follow-up and had a palpable radial pulse.

In contradistinction to bypass surgery, repeat procedures can be easily and expeditiously performed at any time during the follow-up period, if clinically indicated. In addition, further carotid endarterectomies or coronary bypass surgeries can be done without fear of damaging any surgically implanted conduit.

PTA of the subclavian or innominate artery is technically feasible, has an excellent success rate, has a low incidence of complications and restenosis, and should be considered the preferential treatment for subclavian/innominate arterial lesions. The brachial approach should be preferential to the femoral approach in occluded vessels to overcome the potential problem of embolization into the brachial artery or its tributary arteries.

The indications for subclavian PTA are those in which the patients will gain clinical benefit from the procedure and go beyond the indication of a symptomatic subclavian steal syndrome. Presently, there does not appear to be a clinical situation that is a contraindication to PTA or preferential indication for surgery.

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