Management of Digital Emboli, Vasospasm, and Ischemia in ATOS

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Abstract

Unilateral digital ischemia is one of the most common presenting problems in patients with arterial TOS, leading to numbness, tingling, cold and painful sensations, cyanotic or pale discoloration, delayed capillary refill in the fingers, and non-healing fingertip ulceration. Diagnostic evaluation requires differentiation between proximal and distal arterial sources of thromboembolism, localized digital artery occlusion, and primary vasospasm. Digital emboli typically accompany arterial TOS as a result of mural thrombus formed within an area of aneurysmal degeneration in the subclavian (or axillary) arteries. While there are a variety of medical treatments to help reduce local symptoms of digital ischemia and vasospasm, definitive management depends on surgical control of the proximal source of thromboembolism. Additional interventions, such as thromboembolectomy and intra-arterial infusion of thrombolytic agents and/or vasodilators, are valuable adjuncts toward achieving optimal outcomes.

Clinical Presentation

Unilateral digital ischemia is one of the most common presenting problems in patients with arterial TOS [1, 2]. The principal symptoms include numbness, tingling, cold and painful sensations, cyanotic or pale discoloration, and delayed capillary refill in the fingers. Non-healing fingertip ulceration may be present, particularly in patients with longstanding symptoms (Fig. 79.1). On physical examination the brachial, radial and/or ulnar pulses may be absent or decreased in the presence of a proximal arterial occlusion, with diminished blood pressure in the affected arm. Digital ischemia may also exist with

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K.A. Illig et al. (eds.), *Thoracic Outlet Syndrome*,
DOI 10.1007/978-1-4471-4366-6_79,

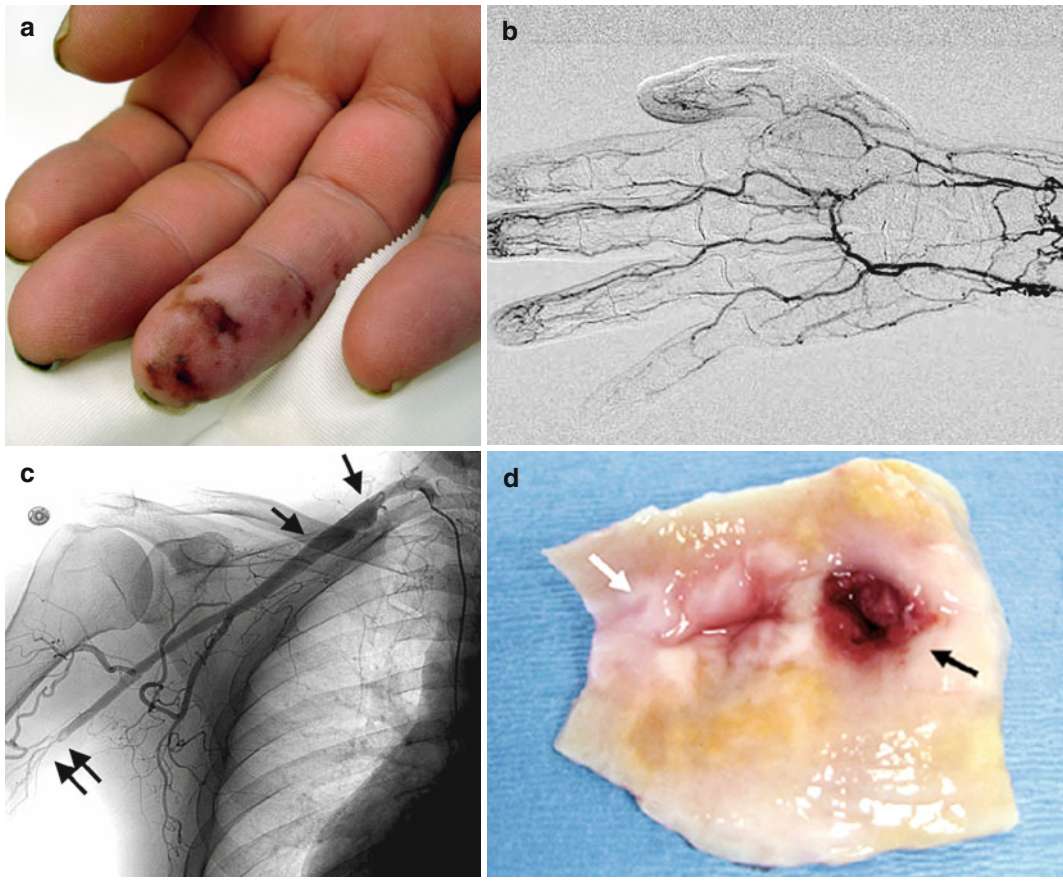

Fig. 79.1 Digital ulceration due to arterial emboli. Patient presenting with non-healing fingertip ulcerations in the *right hand* (**a**). Arteriography demonstrated digital artery occlusions due to emboli from a proximal source (**b**), and revealed a proximal brachial artery occlusion (**c**, *double arrows*) and a subclavian artery aneurysm (**c**, *arrows*). A right cervical rib was also present. Following thoracic outlet decompression with resection of the cervical and first ribs, the subclavian aneurysm was excised and the subclavian artery repaired with an interposition bypass graft. The surgical specimen demonstrated intimal thickening (**d**, *white arrow*) and a deep intimal ulcer filled with chronic thrombus as the source of distal emboli (**d**, *black arrow*)

normal radial and ulnar pulses if the site of arterial obstruction is solely within the vessels of the hand, which can occur with digital artery embolism from a more proximal site or with digital artery thrombosis secondary to local trauma. Digital ischemia usually coexists with and is exacerbated by local vasospasm and cold intolerance. In some circumstances, primary vasospasm can also result in digital ischemia in the absence of arterial thrombosis or embolism. The potential causes of digital ischemia are summarized in Table 79.1.

Diagnosis

The diagnostic evaluation of digital ischemia requires differentiation between proximal and distal arterial sources of thromboembolism, localized digital artery occlusion, and primary vasospasm [3]. Upper extremity embolism arising from the heart usually leads to occlusion of the axillary or brachial arteries by a relatively large thrombus, and can be effectively evaluated by echocardiography and Duplex ultrasound studies of the upper extremity. In most cases of distal embolism

Table 79.1 Differential diagnosis of digital ischemia

Thromboembolism from a cardiac source
Arrhythmia, valvular disease, septal defect (paradoxical)
Thromboembolism from a proximal arterial source
Aorta: endothelial erosion, ulceration, or penetrating ulcer
Subclavian or axillary arteries: aneurysm, occlusion, stenosis or ulceration
Thromboembolism from a distal arterial source
Brachial, radial or ulnar arteries: local trauma
Palmar arteries: hypothenar hammer syndrome
Systemic diseases associated with vasculitis
Scleroderma, rheumatoid arthritis, polyarteritis nodosa, takayasu's, beurger's disease
Local vascular diseases
Hemangioma, arteriovenous malformation, glomus tumor, synovitis
Primary digital artery thrombosis
Local repetitive trauma
Primary vasospasm
Raynaud's disease, cold exposure, tobacco use, cocaine

in a young, otherwise healthy individual, an arterial source must be considered. Although vascular laboratory studies may increase suspicion of an arterial lesion, this is best evaluated by catheter-based (transfemoral) selective arteriography, with positional views of the neck and upper arm and high-resolution views of the hand (Fig. 79.2). This may also be accomplished in some settings with contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI), but catheter-based arteriography remains the most accurate and definitive approach.

If a proximal arterial source of embolism cannot be identified, primary digital artery thrombosis and/or vasospasm is suspected. Digital artery thrombosis can be caused by localized repetitive trauma, such as that occasionally seen in baseball players secondary to pressure exerted on a specific site in the index or middle finger when gripping or throwing the ball. Another arterial lesion localized within the hand is the "hypothenar hammer" syndrome, where degeneration of the distal ulnar artery as it crosses the hamate bone is caused by chronic repetitive trauma to the base of the hand, resulting in thromboembolism to the digital arteries. Finally, primary digital artery spasm (in the absence of embolism or thrombosis) may be the result of localized injury in combination with sustained cold exposure and/or use of tobacco, cocaine or other vasoconstrictive agents.

Digital emboli typically accompany arterial TOS as a result of aneurysmal degeneration in the subclavian or axillary arteries (Figs. 79.1, 79.2, and 79.3) [4–7]. Mural thrombus formed within an aneurysm in these locations is particularly prone to embolize to distal vessels, since the axillary and subclavian arteries are subject to a great deal of motion during the course of normal daily upper extremity activity, and because arterial TOS is usually associated with cervical ribs or other bony anomalies [8]. Embolic occlusion may occur in the distal brachial, radial or ulnar arteries, or may be confined to the small digital vessels.

Treatment

A variety of medical treatment options have been described for the initial treatment of digital ischemia and vasospasm (Table 79.2) [3]. While these measures may help reduce local symptoms, definitive management depends on identifying the underlying cause and surgical treatment for any proximal and/or distal arterial lesion. In many cases ongoing medical treatment for digital ischemia is also required despite satisfactory surgical control of the proximal source of thromboembolism, such as a subclavian artery aneurysm. This may include interventions such as thromboembolectomy and intra-arterial infusion of thrombolytic agents and/or vasodilators, either at the time of the principal operation or as secondary procedures performed during the follow-up period. Cervical sympathetic (stellate ganglion) blockade with local anesthetic is a useful adjunct in differentiating persistent digital vasospasm that may be responsive to vasodilator treatment. If sympathetic blockade provides effective but only short-duration relief of finger and hand symptoms, surgical approaches to cervical sympathectomy or digital artery sympathectomy can also be considered. While cervical sympathectomy can be readily performed in conjunction with primary thoracic outlet decompression procedures,

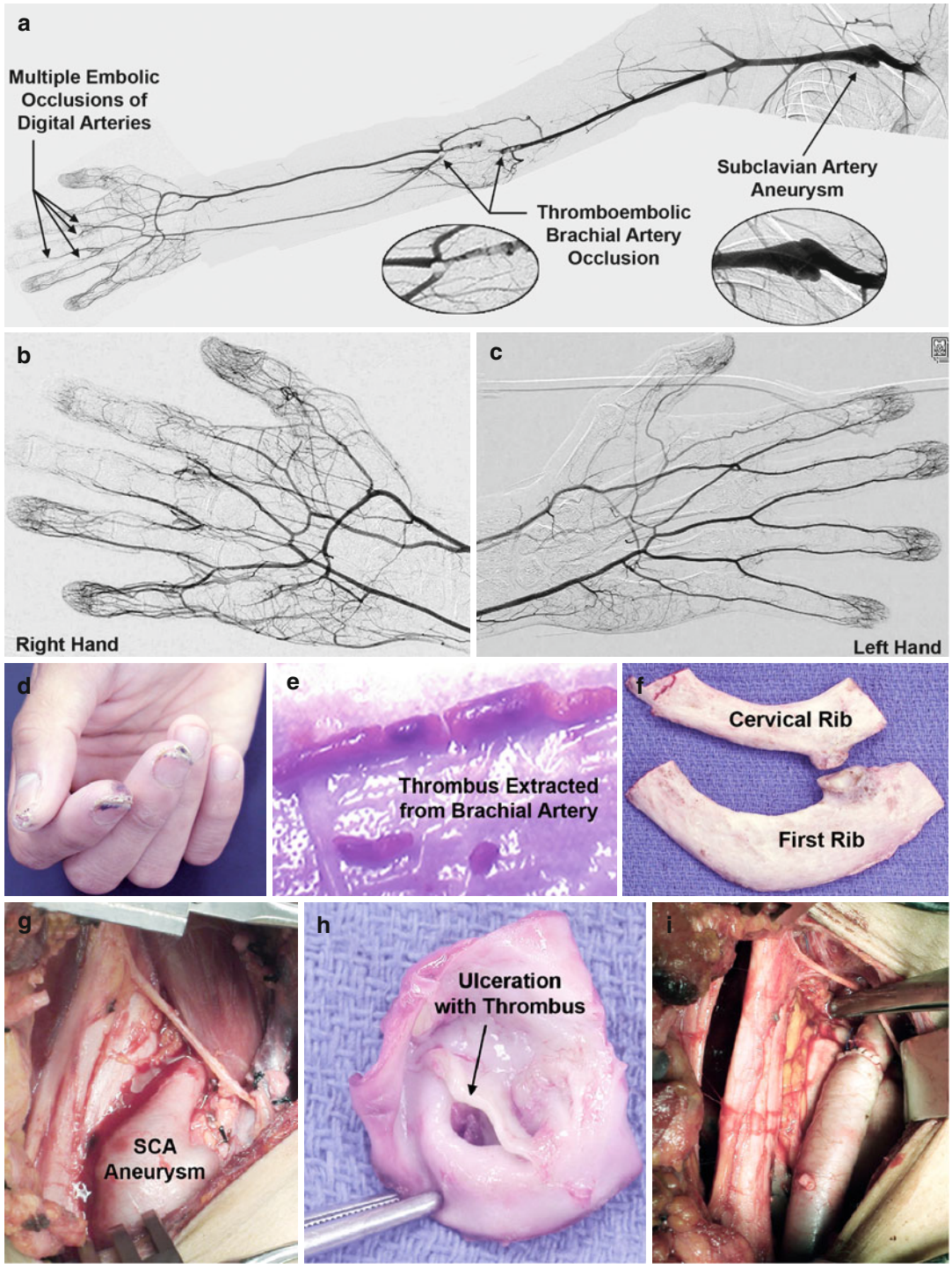

Fig. 79.2 Subclavian artery aneurysm causing digital ischemia. Patient presenting with right hand ischemia, with an upper extremity arteriogram demonstrating a subclavian artery aneurysm, thromboembolic occlusion of the distal brachial artery, and multiple embolic digital artery occlusions (**a**). Magnified arteriographic views of the affected right hand (**b**) and normal left hand (**c**) illustrate the differences in perfusion that led to ischemic fingertip lesions in the right hand (**d**). A brachial artery thromboembolectomy and patch angioplasty repair was initially performed (**e**), followed several days later by thoracic outlet decompression with resection of the cervical and first ribs (**f**). The subclavian artery aneurysm (**g**) was excised, with the specimen demonstrating intimal ulceration with thrombus (**h**), and an interposition arterial graft repair was performed (**i**)

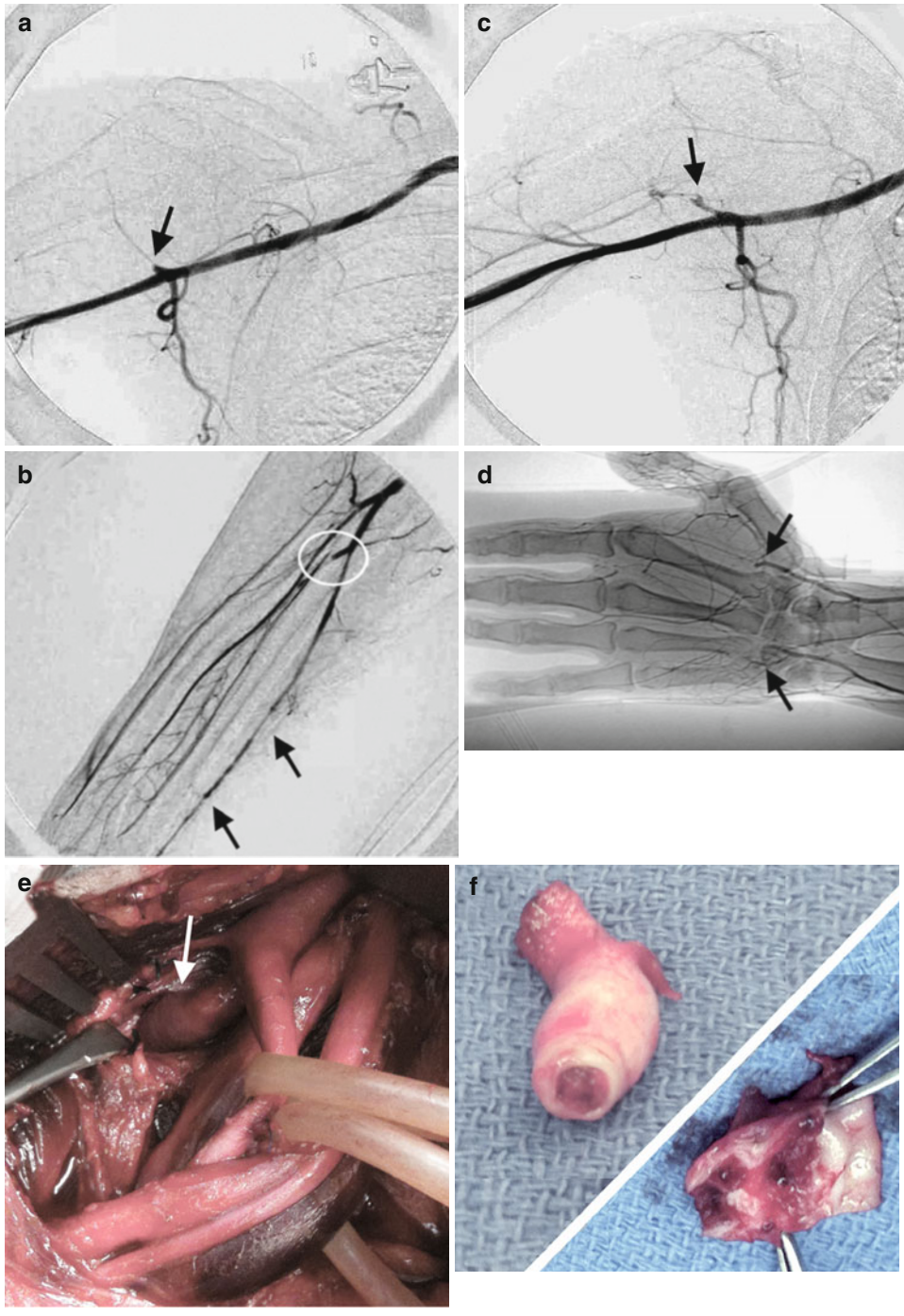

Fig. 79.3 Upper extremity thromboembolism caused by axillary artery branch vessel aneurysms. (**a**–**b**) An otherwise healthy overhead throwing athlete presented with digital ischemia. Arteriography demonstrated occlusion of a right posterior circumflex humeral artery aneurysm (**a**, *arrow*) and multiple emboli to the interosseus and ulnar arteries (**b**, *arrows*). (**c**–**f**) Professional baseball pitcher presenting with digital ischemia in the throwing hand. Arteriography demonstrated occlusion of a right posterior circumflex humeral artery aneurysm (**c**, *arrow*), with embolic occlusion of the radial and ulnar arteries in the hand (**d**, *arrows*). Operative exploration demonstrated a branch vessel aneurysm (**e**, *white arrow*), which was ligated and excised. The operative specimen revealed thrombus within the occluded aneurysmal lesion (**f**) (Adapted from Duwayri et al. [7]. With permission from Elsevier)

Table 79.2 Medical management of digital ischemia

Environmental measures
Eliminate tobacco exposure; avoid cold exposure; limit arm activity
Anticoagulation
Intravenous heparin (Dose adjusted to PTT > 2.5 normal)
Subcutaneous heparin (e.g., lovenox 1 ug/kg sc BID)
Warfarin (Dose adjusted to INR > 2.0)
Antiplatelet agents
Aspirin (325 mg po QD); clopidogrel (75 mg po BID)
Vasodilators
Calcium channel blockers (e.g., nifedipine 10 mg po QID)
ACE inhibitors (e.g., enalapril 5–10 mg po QD)
Angiotensin receptor blockers (e.g., losartan 25–50 mg po QD)
Nitrates (e.g., Topical nitropaste, sublingual TNG prn; isordil 5–10 mg po QD-BID)
Phosphodiesterase-5 inhibitors (e.g., viagra 25 mg po QD)
Pentoxiphylline (e.g., trental 400 mg po TID)
Interventions
Intra-arterial thrombolytic infusions (e.g., TPA)
Intra-arterial vasodilator infusions (e.g., papaverine, PGE)
Cervical sympathetic (Stellate ganglion) blocks

Abbreviations: *ACE* angiotensin converting enzyme, *INR* international normalized ratio, *PGE* prostaglandin E, *PTT* partial thromboplastin time, *TNG* trinitroglycerine, *TPA* tissue plasminogen activator

it is particularly effective when performed as an independent operation using minimally invasive video-assisted thoracoscopic surgery (VATS) approaches [9]. The general outcomes of treatment for patients with digital ischemia and vasospasm are difficult to estimate, since they are largely dependent on the specific cause, extent, and duration of thrombosis, in addition to the specific forms of treatment used.

Intraoperative Administration of Thrombolytic and Vasodilator Agents

For patients with arterial TOS and pronounced digital ischemia that have undergone surgical treatment for the embolic source, intraoperative infusion of vasodilator agents, such as prostaglandin E (PGE) may be an effective means to improve arterial supply to the hand and digits. This approach may also be effective when performed as an independent procedure during follow-up. Initially introduced in our institution by Dr. Juan Parodi, we perform these procedures with intra-arterial access under general anesthesia, due to a substantial amount of pain that can accompany pharmacological vasodilatation in ischemic tissues.

Percutaneous access to the femoral artery is obtained with a small-caliber angiographic sheath and a guidewire is passed into the aorta under fluoroscopic guidance. An arch arteriogram is performed to guide selective placement of the catheter into the distal brachial artery, and high-resolution arteriographic images are obtained of the hand and digits. Intraoperative arterial infusion is performed with approximately 500 mL of saline containing PGE (1 μg/mL). Arterial pressure is closely monitored through the femoral artery sheath and the infusion rate is adjusted to maintain mean blood pressure above 60 mmHg. During PGE infusion there will be obvious vasodilatation in the skin of the forearm and hand, usually with a sharp demarcation just distal to the site of the infusion catheter. Vasodilator infusion is typically followed by intraarterial infusion of a thrombolytic agent, such as 2 mL saline containing 1 mg/mL tissue plasminogen activator (TPA). Following this, infusion of the vasodilator PGE and the thrombolytic agent TPA are alternated over a period of approximately 45 min, to achieve a total of 500 μg PGE and 4–6 mg TPA. Repeat arteriography is performed at the end of the procedure to demonstrate if there is improved perfusion of the hand and digital arteries, but occlusive lesions of the digital vessels are typically unchanged. Nonetheless, most patients exhibit a marked improvement, with the hand and fingers appeared warm, pink and well-perfused, with brisk capillary refill. Intra-arterial infusion of vasodilator and thrombolytic agents may be repeated several times over a period of 1–2 months, in an effort to obtain maximal and long-lasting improvement.

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