Compartment Syndrome of the Arm Caused by Transcatheter Angiography or Angioplasty

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Abstract

Compartment syndrome of the arm is a rare condition because of the large capacity of the arm compartment. Although several cases of compartment syndrome of the forearm associated with vascular access procedures have been reported, the literature contains few detailed reports of compartment syndrome of the arm caused by transcatheter angiography or angioplasty. This article presents 4 cases of compartment syndrome of the anterior arm caused by transcatheter angiography or angioplasty; all patients required surgical treatment and anticoagulation therapy. Following urgent fasciotomy and hemostasis, 1 patient experienced recurrent bleeding and another exhibited delayed complex regional pain syndrome of the forearm. The remaining 2 cases had good outcomes.

Because all patients had been prescribed various oral anticoagulants, their compartment syndrome was considered a complication of thrombolytic therapy. In addition, because all patients had a history of multiple arterial diseases, atherosclerosis was considered to be severely advanced and the vessels to be easily damaged. Due to the authors’ experiences with these 4 cases, they recommend that surgery be performed under general rather than local anesthesia and that the bleeding site be sutured or ligated. Compression of the bleeding point alone could allow heavy bleeding or recurrence of bleeding to occur because of the influence of anticoagulation therapy. Continuous bleeding of the arm may expand into the volar compartment of the forearm, leading to a condition similar to chronic compartment syndrome. Effective hemostasis, in addition to early decompressive fasciotomy, is essential in compartment syndrome caused by the catheter procedure.

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Compartment syndrome of the arm is a rare condition because of the large capacity of the arm compartment. Several reports on compartment syndrome of the arm caused by a crushing injury, tendon rupture of the biceps and triceps, traumatic brachial artery injury, compression, prolonged tourniquet use, use of a blood pressure monitor, and venipuncture in a patient with hemophilia have been published. To the current authors’ knowledge, only 1 case of compartment syndrome of the arm secondary to a catheter-induced procedure has been reported; as a complication of thrombolytic therapy, the patient sustained acute compartment syndrome of the posterior arm accompanied by radial and ulnar nerve palsy after cardiac catheterization.

The current article reports 4 cases of compartment syndrome of the anterior arm caused by transcatheter angiography or angioplasty; all patients required surgical treatment. Patients provided informed consent for data concerning their cases to be submitted for publication.

Case Reports

Patient 1
A 55-year-old woman with stenosis of the left subclavian artery was admitted to the authors’ hospital. She had a history of homozygous familial hypercholesterolemia, systemic arteriosclerosis obliterans, coronary artery disease, and cerebral infarction. She received oral anticoagulation therapy with aspirin and ticlopidine hydrochloride. Her coagulation laboratory tests were normal, but her platelet count was 6.0x10^4 cells/µL at admission.

Angioplasty of the left subclavian artery was performed the following day via the right brachial artery through a 7-Fr sheath using a bare metal stent. Thirty minutes after stenting, she reported marked pain in her anterior arm. The surgeon consulted the authors, suspecting acute compartment syndrome. The anterior arm was considerably swollen, stiff, and tender.

The authors used the Whitesides method to measure the intracompartmental pressure of the patient’s anterior arm. The pressure in the anterior compartment reached 50 mm Hg, and the delta pressure (Δp) (ie, the difference between the diastolic blood pressure and the compartment pressure) was 11 mm Hg. Magnetic resonance imaging showed a large hematoma in the anterior compartment of the upper arm (Figure). Compartment syndrome of the anterior aspect of the arm was diagnosed, and an urgent open fasciotomy was performed while she was under local anesthesia.

A longitudinal incision was made over the anterior aspect of the brachium. The biceps brachii was considerably swollen with hematoma, and active bleeding was found at the puncture site of the brachial artery. The bleeding point was compressed manually for approximately 30 minutes, but bleeding could not be controlled. The bleeding eventually stopped after additional compression using microfibrilar collagen (Avitene; Davol, Cranston, Rhode Island). Intraoperative blood loss was 560 mL and was replaced by 2 units of packed red blood cells via transfusion. The wound was left open.

Postoperatively, the cardiologist ordered continuation of anticoagulants because of the high risk of occlusive vascular disease. On postoperative day 12, recurrent bleeding occurred when the patient strained during defecation; it took 1 hour to stop the bleeding using manual compression. On postoperative day 22, the wound was closed and the patient achieved complete recovery without neurological impairment.

Patient 2
A 64-year-old man with asymptomatic myocardial ischemia was admitted to the authors’ hospital. He had a history of hypertension, diabetes mellitus, and bilateral arteriosclerosis obliterans of the lower legs. He was taking oral anticoagulation therapy with aspirin and clopidogrel sulfate. Two months previously, he had undergone diagnostic coronary angiography via the transfemoral approach, which revealed severe stenosis of the left anterior descending coronary artery and left circumflex coronary artery.

His coagulation laboratory tests were normal at admission. Stenting of the left anterior descending coronary artery was successfully performed via the right bra-
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chial artery through a 7-Fr sheath because of the presence of arteriosclerosis obliterans in the lower leg. One week later, stenting of the left circumflex coronary artery was performed via the same approach. Soon after the procedure ended, he reported marked pain and tenderness in the anterior aspect of the arm, which was becoming markedly stiff and swollen, and hypoesthesia and paralysis of the right thumb and index finger appeared within 30 minutes.

The authors used the Whitesides method to measure the intracompartmental pressure of the patient’s anterior arm.13 The intracompartmental tissue pressure was 50 mm Hg and \( \Delta p \) was 2 mm Hg. Although the posterior arm and forearm were slightly swollen, the compartment pressures were less than 5 mm Hg. Compartment syndrome of the anterior arm was diagnosed, and an open decompressive fasciotomy was performed immediately while he was under general anesthesia.

An incision was made over the anterior aspect of the brachium when the biceps brachii appeared to be markedly swollen with a hematoma, and active bleeding was found at the puncture site of the brachial artery. Bleeding was controlled by suturing the bleeding site. The wound was left open for 8 days to allow edema to resolve. On postoperative day 8, the wound was closed. However, the patient reported persistent pain and tenderness of the volar aspect of the forearm. Although he had been treated by medication and stellate ganglion block under the diagnosis of complex regional pain syndrome, he reported persistent pain without neurological impairment at 31-month follow-up.

**Patient 3**

An 80-year-old man with a history of myocardial infarction was admitted to the authors’ hospital. He had a history of arteriosclerosis obliterans of the lower legs, cerebral infarction, and coronary artery disease treated with multiple catheter intervention of the right coronary and left circumflex coronary arteries. He received oral anticoagulation therapy with ticlopidine hydrochloride and cilostazol.

His coagulation laboratory tests were normal at admission. Routine coronary angiography via the right brachial artery was performed through a 5-Fr sheath the following day. The brachial introducer sheath was removed immediately after the procedure, and brachial compression was applied as usual with a bandage. One hour later, he reported pain and tenderness on the anterior aspect of his right arm.

The authors used the Whitesides method to measure the tissue pressure in the anterior compartment of the arm.13 The intracompartmental tissue pressure was 40 mm Hg and \( \Delta p \) was 19 mm Hg. Compartment syndrome of the anterior aspect of the arm was diagnosed, and an urgent fasciotomy was performed while he was under general anesthesia. Hematoma formation in the biceps brachii muscle and active bleeding from a branch of the brachial artery were found. Bleeding was stopped with ligation. One week after the fasciotomy, he underwent complete closure of the entire wound and achieved complete recovery without neuromuscular problems.

**Patient 4**

A 79-year-old woman with an existing myocardial infarction was admitted to the authors’ hospital. She had undergone multiple percutaneous coronary interventions and had been taking oral anticoagulation therapy with aspirin and clopidogrel sulfate. Her coagulation laboratory tests were normal at admission.

The following day, she underwent coronary angiography via the right transradial approach through a 5-Fr sheath. The sheath was removed immediately after the procedure with no problems, and compression of the puncture site was applied with a bandage as usual. Thirty minutes later, she reported pain and tenderness on the anterior aspect of her right arm.

The authors used the Whitesides method to measure the tissue pressure in the anterior compartment of the arm.135 The intracompartmental tissue pressure was 50 mm Hg and \( \Delta p \) was 4 mm Hg. Compartment syndrome of the anterior aspect of the arm was diagnosed, and an urgent open decompression fasciotomy was performed while she was under general anesthesia. Surgical examination revealed edema of the muscles of the anterior compartment, hematoma formation in the biceps, and active bleeding from a branch of the brachial artery. The authors were able to stop the bleeding with ligation, and the wound was left open for 10 days. On postoperative day 10, the wound was sutured. The patient recovered and was discharged, with full movement of her upper extremity having been obtained.

**DISCUSSION**

Acute compartment syndrome occurs when pressure within closed myofascial spaces containing muscles, arteries, veins, and nerves is markedly increased. For a definitive diagnosis of compartment syndrome, it is useful to measure intracompartmental tissue pressure. Hargens et al14 proposed that fasciotomy be performed when the absolute compartment pressure is more than 30 mm Hg.

Whitesides et al13 and Whitesides and Heckman15 reported that the tissue perfusion of the compartment depends on the difference between the diastolic blood pressure and the intracompartmental pressure, known as the \( \Delta p \). They stated that a \( \Delta p \) less than 20 mm Hg indicates the need for fasciotomy.15 The authors also monitored intracompartmental tissue pressure using the Whitesides method in suspected patients. In all cases, the absolute intracompartmental pressure of the anterior arm was more than 30 mm Hg and \( \Delta p \) was less than 20 mm Hg, supporting the early diagnosis of the compartment syndrome.

Ricci et al16 described iatrogenic vascular complications, such as hematoma, bleeding, pseudoaneurysm, thrombo-
embolism, and arteriovenous fistula, occurring at a rate of 1% after diagnostic transcatheater angiography, and this incidence increased to 3% after angioplasty. Kiemeneij et al. reported a 2.3% incidence of entry site–related bleeding complications, such as hematoma and pseudoaneurysm, after transbrachial coronary angioplasty, whereas no bleeding complications were recorded after the transradial procedure.

To the current authors’ knowledge, 7 cases of compartment syndrome of the forearm due to bleeding following the transradial approach have been reported, wherein an incidence of 0.004% was suggested after a review of 51,296 patients. However, to the authors’ knowledge, only 1 case of compartment syndrome of the arm secondary to a catheter procedure has been reported in the literature, in which compartment syndrome as a complication of thrombolytic therapy after myocardial infarction.

The arm is separated into the anterior and posterior compartments by the intermuscular septa. The anterior compartment contains the biceps brachii, brachialis, and coracobrachialis muscles; median nerve; proximal part of the ulnar nerve; distal part of the radial nerve; medial antebrachial cutaneous nerve; and lateral antebrachial cutaneous nerve. These structures are all at risk of injury if tissue pressure is elevated. The posterior compartment contains the triceps muscle, proximal part of the radial nerve, distal part of the ulnar nerve, and posterior antebrachial cutaneous nerve. The brachial fascia surrounding the contents of the compartments is thinner and tends to yield more readily than the fascia of the forearm or leg. Therefore, the arm compartment has a greater capacity for swelling, which correlates with the low incidence of compartment syndrome in the arm. The brachial artery runs alongside the median nerve, down the medial border of the anterior compartment, under the biceps brachii muscle, and onto the brachialis muscle. From an anatomical point of view, compartment syndrome of the arm due to injury of the brachial artery is considered to be a more likely incident in the anterior compartment than in the posterior compartment. Although posterior compartment syndrome can occur after cardiac catheterization, other etiologies such as minor trauma may correlate mainly with posterior compartment syndrome.

The current authors reported 4 cases of compartment syndrome of the arm due to transcatheater angiography or angioplasty. Because all patients had been treated with various oral anticoagulants, compartment syndrome was considered a complication of anticoagulation therapy, as described by Segal and Adair. In addition, because all patients had a history of multiple arterial diseases, atherosclerosis was considered to be severely advanced and the vessels to be easily damaged. In 2 patients who underwent angioplasty, the large sheath size of 7 Fr, which is sometimes necessary for angioplasty of large arteries, might have been associated with severe bleeding leading to compartment syndrome.

Effective hemostasis, in addition to early decompressive fasciotomy, is considered necessary in compartment syndrome caused by the catheter procedure. In the authors’ experience with these 4 cases, they recommend that the surgery be performed under general rather than local anesthesia and that the bleeding site be sutured or ligated. Compression of the bleeding point alone can allow heavy bleeding or recurrence of bleeding because of the influence of anticoagulation therapy. Complex regional pain syndrome of the forearm occurred even after early decompression fasciotomy of the anterior arm and suture of the bleeding site of the brachial artery in 1 patient. Because the authors retrospectively evaluated this patient’s clinical course, they believe that continuous bleeding of the arm might have expanded into the volar compartment of the forearm, leading to a condition similar to chronic compartment syndrome.

**Conclusion**

To treat compartment syndrome of the anterior arm due to transcatheater angiography or angioplasty, effective hemostasis and early decompressive fasciotomy are essential.

**References**


