elSSN 2287-1683
plSSN 1738-8767
Journal of Trauma and Injury
Vol. 26, No. 3, September, 2013

• Case Report •
[J Trauma Inj 2013;26:243-247]

다발성 외상환자에서 혈관계 접근을 통해 치료한 쇄골하동맥 손상 2례

[1]경북대학교병원 외상센타, [2]경북대학교 의학전문대학원 외과학교실

조자윤[1,2], 정희경[2], 김형기[2], 임경훈[1], 박진영[1,2], 허 승[2]

- Abstract -

Treatment of Subclavian Artery Injury in Multiple Trauma Patients by Using an Endovascular Approach: Two Cases

Jayun Cho, M.D., RVT, RPVI[1,2], Heekyung Jung, M.D.[2], Hyung-Kee Kim, M.D.[2], Kyoung Hoon Lim, M.D.[1,2], Jinyoung Park, M.D.[1,2], Seung Huh, M.D., Ph.D.[2]

[1]Trauma Center, Kyungpook National University Hospital, Daegu, Korea
[2]Department of Surgery, Kyungpook National University School of Medicine, Daegu, Korea

Introduction: Surgical treatment of subclavian artery (SA) injury is challenging because approaching the lesion directly and clamping the proximal artery is difficult. This can be overcome by using an endovascular technique.

Case 1: A 37-year-old male was drawn into the concrete mixer truck. He had a right SA injury with multiple traumatic injuries: an open fracture of the right leg with posterior tibial artery (PTA) injury, a right hemothorax, and fractures of the clavicle, scapula, ribs, cervical spine and nasal bone. The injury severity score (ISS) was 27. Computed tomography (CT) showed a 30-mm-length thrombotic occlusion in the right SA, which was 15 mm distal to the vertebral artery (VA). A self-expandable stent(8 mm×40 mm in size) was deployed through the right femoral artery while preserving VA flow, and the radial pulse was palpable after deployment. Other operations were performed sequentially. He had a viable right arm during a 13-month follow-up period.

Case 2: A 25-year-old male was admitted to our hospital due to a motorcycle accident. The ISS was 34 because of a hemothorax and open fractures of the mandible and the left hand. Intraoperative angiography was done through a right femoral artery puncture. Contrast extravasation of the SA was detected just outside the left rib cage. After balloon catheter had been inflated just proximal to the bleeding site, direct surgical exploration was performed through infraclavicular skin incision. The transected SA was identified, and an interposition graft was performed using a saphenous vein graft. Other operations were performed sequentially. He had a viable left arm during a 15-month follow-up period.

Conclusion: The challenge of repairing an SA injury can be overcome by using an endovascular approach.

Key Words: Subclavian artery, Vascular system injuries, Endovascular procedures

* Address for Correspondence : **Seung Huh, M.D., Ph.D.**
Department of Surgery, Kyungpook National University Hospital,
130 Dongduk-Ro, Jung-Gu, Daegu 700-721, Korea
Tel : 82-53-420-6520, Fax : 82-53-421-0510, E-mail : shuh@knu.ac.kr

Submitted : July 31, 2013 **Revised** : August 24, 2013 **Accepted** : September 2, 2013

I. Introduction

Surgical treatment of subclavian artery (SA) injury is challenging. It is difficult to approach the lesion directly due to deep anatomy. Extensive dissection may be required for proximal arterial control which is sternotomy, thoracotomy or resection of the clavicle.(1) Therefore the iatrogenic injury of nerve, lymphatics or pleura may occur frequently. This situation precludes rapid access to the injured lesions, and its morbidity and mortality is high.(1) However, it could be overcome by using endovascular technique in the endovascular era.

In the western data, penetrating trauma is the most common in the SA injury, while blunt trauma is extremely rare.(2) In the Republic of Korea where gun control is very strict, penetrating trauma is so fewer than western countries that SA injury itself is rare. In this report, we describe the endovascular approach in the treatment of blunt SA injury and the review of literature.

II. CASE DESCRIPTION

1. Case 1

A 37-year-old schizophrenic male patient was drawn into the concrete mixer truck and had blunt trauma on the right shoulder. He had right SA injury with multiple traumatic injuries which was open fracture of right distal lower leg with posterior tibial artery (PTA) injury, right hemothorax and fractures of clavicle, scapula, ribs, cervical spine and nasal bone. Injury severity score (ISS) was 27. His initial vital sign indicated a blood pressure of 74/43 mmHg and a heart rate of 80 beats/minute, however it became stable after resuscitation. Computed tomography (CT) angiography showed 30-mm-length thrombotic occlusion in right SA which was 15 mm distal to vertebral artery (VA) (Fig. 1). Self-expandable stent(8×40 mm sized; Complete SE, Medtronic Vascular, Santa Rosa, CA) was deployed in the occluded right SA after intraoperative diagnostic angiography through right femoral artery puncture while preserving VA flow. After that, balloon angioplasty(7×40 mm sized; Powerflex P3, Cordis Corporation, Miami, FL) was done on the inside of the stent. Heparin was not administrated

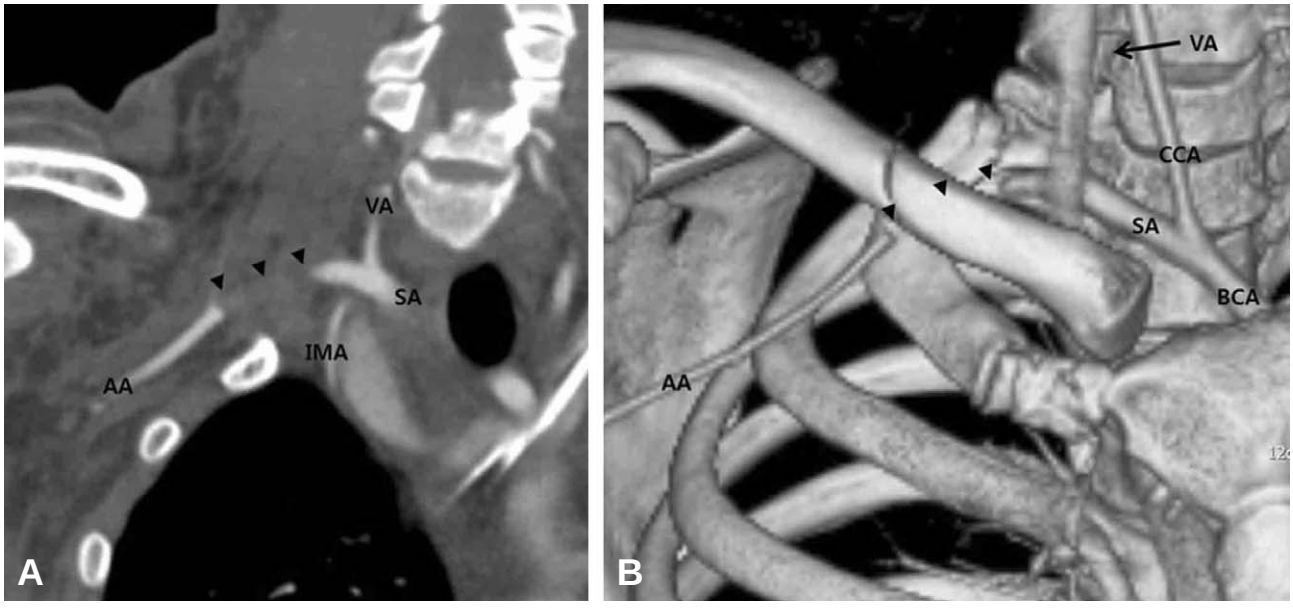

Fig. 1. Computed tomography (CT) (**A**) and CT angiography (**B**) showed 30-mm-length thrombotic occlusion (arrowheads) in right subclavian artery (SA) which was 15 mm distal to vertebral artery (VA). AA: axillary artery, IMA: internal mammary artery, CCA: common carotid artery, BCA: brachiocephalic artery

due to other multiple injuries. Intraoperative completion angiography showed patent stent and successful revascularization (Fig. 2). And radial artery pulse was palpable after stent deployment. Other operations were performed sequentially which were interposition graft in the transected paramalleolar PTA lesion using saphenous vein, open reduction and internal fixation (OR/IF) of tibia and closed reduction of nasal bone. The surgeries lasted 11 hours in aggregate, during which the patient received 3 units of packed red blood cells. Stent was patent on CT 2 days later (Fig. 2). He had a viable right arm during a 13-month follow-up period without any antithrombotics. However, unfortunately he was not able to move it due to brachial plexus injury.

2. Case 2

A 25-year-old previously healthy male patient was injured by motorcycle accident and had blunt trauma on the left shoulder. CT showed that left SA

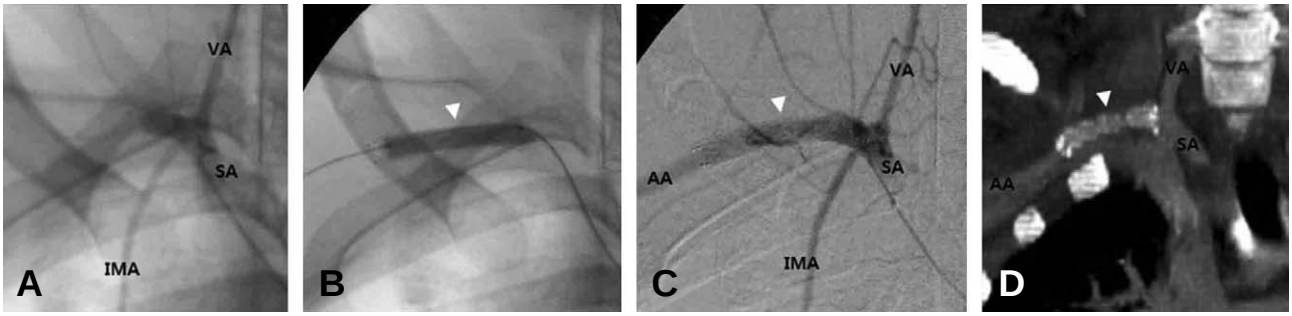

Fig. 2. Self-expandable stent (8×40 mm sized) (white arrowheads) was deployed (**B**) in the occluded right subclavian artery (SA) after intraoperative diagnostic angiography (**A**) through right femoral artery puncture while preserving vertebral artery (VA) flow. Intraoperative completion angiography (**C**) showed patent stent which was the same on computed tomography (**D**) 2 days later. IMA: internal mammary artery, AA: axillary artery

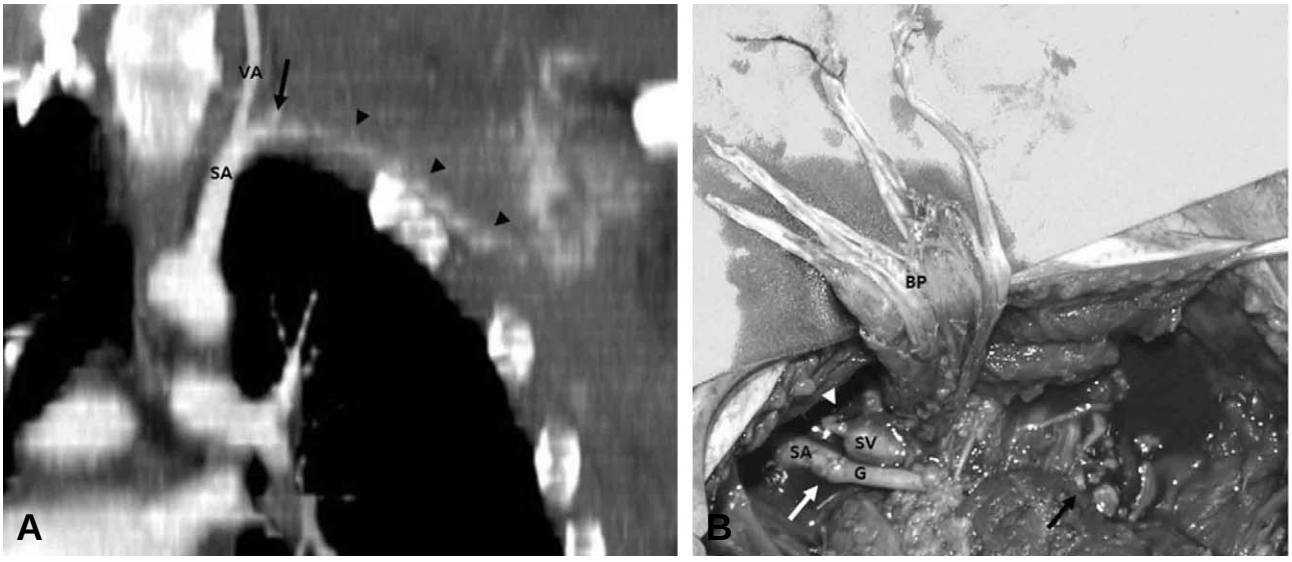

Fig. 3. Computed tomography (**A**) showed that left subclavian artery (SA) was ruptured and extravasated (black arrowheads) which was 20 mm distal to vertebral artery (VA) just outside the left rib cage. After balloon catheter was inflated just above the bleeding site (black arrow of A) on the intraoperative angiography through right femoral artery puncture, direct surgical exploration was performed through infraclavicular skin incision (**B**). Transected SA was identified, and interposition graft in the transected lesion was performed using saphenous vein graft (G). Intraoperative pictures (B) showed proximal (white arrow) and distal (black arrow) anastomosis of interposition graft, ligated distal subclavian vein (SV) (white arrowhead) and injured brachial plexus (BP) which was pulled up by the roots

was ruptured and extravasated which was 20 mm distal to VA (Fig. 3). ISS was 34 because of left hemothorax, open fracture of mandible and left hand. His initial vital sign indicated a blood pressure of 70/35 mmHg and a heart rate of 144 beats/minute, however it became stable after resuscitation. Intraoperative angiography was done through right femoral artery puncture. Contrast extravasation of SA was detected just outside the left rib cage. After balloon catheter(6×40 mm sized; Powerflex P3, Cordis Corporation, Miami, FL) was inflated just above the bleeding site on the intraoperative angiography, direct surgical exploration was performed through infraclavicular skin incision. Transected SA was identified, and interposition graft in the transected lesion was performed using saphenous vein. Only local heparin solution was administrated due to other multiple injuries. Subcalvian vein was also transected, and ligated due to damage control. And we identify brachial plexus injury which was pulled up by the roots (Fig. 3). Fasciotomy of volar aspect of left arm and OR/IF of left metacarpal bones was performed sequentially, and radial artery pulse was palpable. The surgeries lasted six and a half hours in aggregate, during which the patient received 27 units of packed red blood cells. OR/IF of mandible was performed 3 weeks later. Saphenous vein graft was patent on CT 9 days later. He had a viable left arm during a 15-month follow-up period without any antithrombotics. However, unfortunately he was not able to move it due to brachial plexus injury.

III. Discussion

In the western data, penetrating trauma is the most common in the SA injury; 74% is gunshot wounds, and 26% stab wounds.(1) However, this may be different in the Republic of Korea where gun control is very strict. SA injury is usually associated with subclavian vein injury(50%),(3) brachial plexus injury(31%),(4) musculoskeletal fractures and pulmonary contusions. Prehospital mortality is 50 to 80%.(5) Brachial plexus injury is more common in the blunt trauma and is the significant morbidity in the long term.(6) Intimal disruption and dissection which is not flow limiting can be treated conservatively, while thrombotic occlusion, perforation, transection, pseudoaneurysm and arteriovenous fistula should be considered to repair.(7)

There are no studies published with good quality that report the results of open repair versus endovascular treatment of SA injury, because published studies about endovascular treatment are confined to case reports and case series. Xenos et al.(8) and Shalhub et al.(9) report a shorter operative time and lower blood loss in the endovascular treatment, while similar 12-month patency rates in both groups.(8)

In the open repair, interposition graft with polytetrafluoroethylene (PTFE) can be performed with good patency.(3) If the operating field is contaminated, saphenous vein can be used. Early failure rates of open repair is about 5%,(10) and mortality of isolated SA injury is 20.5%.(1) On the other hand, endovascular techniques can reduce need for anesthesia, decrease the morbidity and prevent iatrogenic nerve injury and extensive dissection in the traumatized field. DuBose et al.(7) reports 96.9% for the initial success rates of stent deployment, 84.4% for stent patency during 70 months and no mortality in the review of 32 published reports or case series from 1996 to 2012. du Toit et al.(11) reports 5%(3/56) for early stent thrombosis and long-term results of 20% for significant stenosis during mean 11 months and 12% for occlusion during mean 26 months with a technical success rate of 100% and no procedure-related deaths.

Endovascular technique is usually stent or stent graft deployment on the injured vascular lesions. Stent graft can be deployed especially on the transected lesions, or can be a temporary fix for a more durable open repair later. In the case of open repair, remote occlusive balloon can be used either for proximal artery control from femoral artery or for distal artery control from brachial artery, rather than only direct exploration. Femoral artery approach enables to identify the side branches such as VA. While brachial artery approach is more direct, shorter and less tortuous. Therefore rapid approach to the lesions and identification of intraluminal position of guidewire is possible.(8)

Sometimes rendezvous technique from both femoral and brachial artery may be required for proper position of guidewire.(8)

Care should be taken in the endovascular treatment as follows. Accidental coverage of the VA can develop stroke. In the case of a signi?cant luminal size discrepancy between the proximal and distal artery, tapered stent can prevent endoleak of proximal landing zone and over sizing vessel damage of distal landing zone.(11) Compression between the clavicle and the first rib can lead to stent fracture and occlusion.(11)

It is considered that contraindications of endovascular treatment are hemodynamic instability, vessel transection and absence of an adequate proximal landing zone.(12) A large hematoma with brachial plexus compression may be a relative contraindication; the injured vessel can be treated with a stent graft followed by hematoma evacuation.(11) A young trauma patient is also generally unacceptable due to long-term outcome. However, these days even selected unstable patients underwent endovascular treatment.(13) Endovascular approach enables stent graft coverage or bleeding control with occlusive balloon on the injured lesions rapidly either during the initial acute period or in a delayed fashion after resuscitation for damage control.(14)

It is considered that there are 40 to 50% candidates for endovascular treatment.(8,12) Endovascular treatment has acceptable early and mid-term results, but long-term durability has not yet been well established. Therefore some authors suggest that 'endovascular first' approach may be considered for the SA injury and open approach may be considered 'ready alternative' or a 'bail out' technique.(11,15)

In conclusion, challenging repair of SA injury can be overcome by using endovascular approach

REFERENCES

1) Demetriades D, Chahwan S, Gomez H, Peng R, Velmahos G, Murray J, et al. Penetrating injuries to the subclavian and axillary vessels. Journal of the American College of Surgeons. 1999 Mar;188(3): 290-5.
2) Katras T, Baltazar U, Rush DS, Davis D, Bell TD, Browder IW, et al. Subclavian arterial injury associated with blunt trauma. Vasc Surg. 2001 Feb; 35(1): 43-50.
3) Abouljoud MS, Obeid FN, Horst HM, Sorensen VJ, Fath JJ, Chung SK. Arterial injuries of the thoracic outlet: a ten-year experience. Am Surg. 1993 Sep; 59(9): 590-5.
4) Lin PH, Koffron AJ, Guske PJ, Lujan HJ, Heilizer TJ, Yario RF, et al. Penetrating injuries of the subclavian artery. The American Journal of Surgery. 2003 Jun; 185(6): 580-4.
5) Demetriades D, Rabinowitz B, Pezikis A, Franklin J, Palexas G. Subclavian vascular injuries. Br J Surg. 1987 Nov; 74(11): 1001-3.
6) Johnson SF, Johnson SB, Strodel WE, Barker DE, Kearney PA. Brachial plexus injury: association with subclavian and axillary vascular trauma. J Trauma. 1991 Nov; 31(11): 1546-50.
7) DuBose JJ, Rajani R, Gilani R, Arthurs ZA, Morrison JJ, Clouse WD, et al. Endovascular management of axillo-subclavian arterial injury: A review of published experience. Injury. 2012 Nov; 43(11): 1785-92.
8) Xenos ES, Freeman M, Stevens S, Cassada D, Pacanowski J, Goldman M. Covered stents for injuries of subclavian and axillary arteries. Journal of Vascular Surgery. 2003 Sep; 38(3): 451-4.
9) Shalhub S, Starnes BW, Hatsukami TS, Karmy-Jones R, Tran NT. Repair of blunt thoracic outlet arterial injuries: an evolution from open to endovascular approach. J Trauma. 2011 Nov; 71(5): E114-121.
10) McKinle y AG, Carrim AT, Robbs JV. Management of proximal axillary and subclavian artery injuries. Br J Surg. 2000 Jan; 87(1): 79-85.
11) Du Toit DF, Lambrechts AV, Stark H, Warren BL. Long-term results of stent graft treatment of subclavian artery injuries: Management of choice for stable patients? Journal of Vascular Surgery. 2008 Apr; 47(4): 739-43.
12) Danetz JS, Cassano AD, Stoner MC, Ivatury RR, Levy MM. Feasibility of endovascular repair in penetrating axillosubclavian injuries: A retrospective review. Journal of Vascular Surgery. 2005 Feb; 41(2): 246-54.
13) Stannard A, Eliason JL, Rasmussen TE. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. J Trauma. 2011 Dec; 71(6): 1869-72.
14) Carrick MM, Morrison CA, Pham HQ, Norman MA, Marvin B, Lee J, et al. Modern management of traumatic subclavian artery injuries: a single institution's experience in the evolution of endovascular repair. Am J Surg. 2010 Jan; 199(1): 28-34.
15) Mousa A, Chong B, AbuRahma AF. Endovascular repair of subclavian/axillary artery injury with a covered stent. A case report and review of literature. Vascular [Internet]. 2013 May 7 [cited 2013 Jul 28]; Available from: http://vas.sagepub.com/content/early/2013/05/03/1708538113478754.