Chapter 32
In Patients with Carotid Artery Dissection, Is Stenting Superior to Open Repair to Improve Clinical Outcomes?

Reshma Brahmbhatt and Ravi R. Rajani

Abstract Carotid artery dissection is a rare but potentially devastating entity. Clinical sequale can include stroke, cranial nerve dysfunction, carotid stenosis, and pseudoaneurym formation. Anticoagulation is the mainstay of treatment, but in patients who fail anticoagulation or have contraindications to anticoagulation, surgical therapy is often considered. Open surgical repair had historically been the traditional therapy of choice, but percutaneous therapy with stent placement has become increasingly commonplace. No randomized trials exist regarding optimal surgical management of carotid artery dissection. Current literature supports both open and endovascular treatment as safe and effective for carotid artery dissection.

Keywords Carotid • Dissection • Endovascular • Surgery • Stent

Introduction

Arterial dissection is defined as a disruption or tear in the intimal layer, which allows blood to create false flow lumens within the layers of the arterial wall. The resultant intramural hematoma propagates distally, causing stenosis and possible occlusion of the true flow lumen. Additionally, the weakening of the arterial wall can lead to aneurysmal changes with a potential to become a thromboembolic source. Dissection of the carotid artery can potentially lead to significant complications such as stroke, cranial nerve dysfunction, and aneurysm formation. Carotid

R. Brahmbhatt, MD
Division of Vascular Surgery and Endovascular Therapy,
Emory University School of Medicine, Atlanta, GA, USA

R.R. Rajani, MD (✉)
Division of Vascular Surgery, Department of Surgery, Emory University School of Medicine,
Atlanta, GA, USA
e-mail: r.rajani@emory.edu

C.L. Skelly, R. Milner (eds.), *Difficult Decisions in Vascular Surgery*,
Difficult Decisions in Surgery: An Evidence-Based Approach,
DOI 10.1007/978-3-319-33293-2_32

Table 32.1 PICO table for operative approach to carotid artery dissection

P (Patients)	I (Intervention)	C (Comparator group)	O (Outcomes measured)
Patients with Carotid artery dissection and failed medical management	Endovascular stenting	Open surgery	Stroke, death, cranial nerve injury, patency

dissection is estimated to be the contributing etiology in 2 % of patients who have suffered an index stroke. This is particularly true in younger patients with stroke, where a dissection is identified in as many as 22 % of cases [1–3].

Medical management is the mainstay for uncomplicated carotid dissection. A 2003 Cochrane Database Review found no randomized trials evaluating antiplatelet vs. anticoagulant therapy or either intervention vs. controls [4]. A more recent meta-analysis also noted the lack of randomized data regarding antiplatelet and anticoagulant treatment in carotid artery dissection. However, their results suggested antiplatelet therapy should be given precedence over antcoagulation [5]. The Cervical Artery Dissection in Stroke Study trial (CADISS) is a currently ongoing randomized trial comparing antiplatelet therapy to anticoagulation in cervical artery dissection. Recent publication of their non-randomized arm revealed no difference in 3 month outcomes (stroke, transient ischemic attack, major bleeding, or death) between the two treatment modalities [6]. Despite controversy on whether antiplatelet treatment or anticogulation is ideal, medical management remains the mainstay of treatment for carotid artery dissection. Surgical treatment is reserved only for patients who have a contraindication to anticoagulation (active bleeding, other injuries requiring surgical management, etc.) or for those who fail medical management. Failure of medical management can be described as fluctuating or worsening neurologic symptoms while on medical therapy, severely compromised blood flow, aneurysmal degeneration, and symptomatic aneurysm (including cranial nerve deficit). With the emergence of endovascular techniques for carotid interventions, it is unclear if endovascular approaches improve clinical outcomes when compared to traditional open surgical management (Table 32.1).

Search Strategy

A literature search of English language publications in PubMed, Embase, and Cochrane Evidence Based Medicine databases from inception-2014 was used to identify literature on surgical management of carotid artery dissection. Terms used in the query were “carotid artery dissection”, “cerebrovascular injury”, “cerebrovascular dissection”, “carotid injury” AND “stent”, and “surgery”. Articles were then individually examined and excluded if they did not include a surgical approach to management, did not pertain to the extracranial carotid artery, described thrombolysis only, or were not available online or at a medical library. A total of 65 eligible papers were identified: 45 describing endovascular management, 13 describing open

surgical management, and 7 systematic reviews on overall management. There were no randomized trials. Of the 45 articles on endovascular management, there were 11 retrospective reviews, 5 results of prospective cohorts, and 29 case series. Additionally, there were five general review articles regarding the management of carotid artery dissection and appropriate recommendations. The data was subsequently classified based on the GRADE level of recommendation.

Results

Outcomes After Open Repair

Thirteen articles were identified describing results after open surgical therapy – three retrospective reviews and ten case reports (Table 32.2). Overall, 87 patients are included. The majority of the currently selected articles were published before 1999 [7–19]. While there are a variety of specialties that have reported on this subject, vascular surgery and neurosurgery are most represented. The etiology of dissection was primarily spontaneous or traumatic, though there is one reported iatrogenic injury [8]. Medical management was initially attempted in only 5 of the 13 articles [7, 9, 10, 12, 19]. The most commonly used repair technique was saphenous vein interposition graft, though other techniques such as bypass, endarterectomy, and ligation are also described. Most patients clinically improved following revascularization. While follow-up information is limited, most interposition and bypass grafts appear to have been patent at the time of publication. The largest single series is a retrospective review of 50 patients with symptomatic carotid dissection published in 2000 by Muller et.al. 40 patients underwent saphenous vein interposition grafting, five underwent ligation of the internal carotid artery, three underwent endarterectomy, and two underwent gradual dilation with patch angioplasty. There was one death and 4 strokes (2 from occluded grafts) in the population. There was also a 38 % incidence of cranial nerve injury [19].

Overall, open surgical reconstruction for carotid artery dissection appears to be safe in selected patients based on small case series. There is insufficient evidence to compare standard medical therapy with open surgical reconstruction.

Outcomes After Endovascular Repair

In contrast to the data on open surgical repair of carotid dissection, the majority of data published on carotid stenting for dissection has been published after 2000. Again, there are no randomized trials. The 45 identified manuscripts represent 29 case reports/series, followed by 11 retrospective reviews and 5 reports of prospective cohorts (Table 32.3) [20–64]. Overall, 390 patients are included. Vascular surgery, neurosurgery, and neurointerventional radiology represent the most common

Table 32.2 Open surgical repair of carotid dissection

Study	Patients (n)	Mechanism	Medical management	Intervention	Type of study (grade of evidence)
Aspalter et al. (2013) [14]	2	Traumatic	Not attempted	Interposition vein graft	Case report (low)
Takeuchi et al. (2012) [15]	1	Traumatic	Not attempted	Double-bypass with proximal cervical ICA ligation	Case report (low)
Geraldes, et al. (2012) [16]	1	Spontaneous	Aspirin	CCA interposition graft with synthetic	Case report (low)
Cuff and Thomas (2005) [17]	1	Traumatic	Not attempted	Interposition vein graft	Case report (low)
Findlay et al. (2002) [18]	2	Spontaneous	Not attempted	Embolectomy	Case report (low)
Muller et al. (2000) [19]	50	Spontaneous, traumatic	Failed or not attempted	40 interposition vein graft; 5 carotid ligation; 3 endarterectomy; 2 gradual dilation with patch angioplasty	Retrospective series (low)
Alimi et al. (1998) [7]	8	Traumatic	Failed or not attempted	Interposition vein graft	Retrospective series (low)
Koennecke et al. (1998) [8]	1	Iatrogenic	Not attempted	Interposition vein graft	Case report (low)
Vishteh et al. (1998) [9]	16	Traumatic	Failed or not attempted	Interposition vein graft	Retrospective series (low)
Humphrey et al. (1993) [10]	1	Spontaneous	Failed	Interposition vein graft	Case report (low)
Waespe et al. (1988) [11]	1	Traumatic	Not attempted	EC-IC bypass, occlusion of L ICA aneurysm by detachable balloon	Case report (low)
Miyamoto et al. (1984) [12]	1	Spontaneous	Failed	Superficial temporal to MCA bypass	Case report (low)
Dragon et al. (1981) [13]	2	Traumatic	Not attempted	1 intimal tacking; 1 Interposition vein graft	Case report (low)

ICA internal carotid artery, *CCA* common carotid artery, *MCA* middle cerebral artery, *EC-IC* extracranial-intracranial

Table 32.3 Endovascular stent placement in carotid dissection

Study	Patients (n)	Mechanism	Medical management	Type of study (grade of evidence)
Schulte et al. (2008) [37]	7	Traumatic, iatrogenic	Failed or contraindicated	Prospective cohort (low)
Cohen et al. (2005) [48]	12	Traumatic	Failed or contraindicated	Prospective cohort (low)
Cohen et al. (2005) [49]	10	Traumatic	Failed or contraindicated	Prospective cohort (low)
Cothren et al. (2005) [47]	46	Traumatic	Failed or contraindicated	Prospective cohort (low)
Bassi et al. (2003) [55]	7	Traumatic, spontaneous	Failed	Prospective cohort (low)
Asif et al. (2014)	22	Traumatic, spontaneous	Failed (aspirin and plavix)	Retrospective series (low)
Seth et al. (2013) [23]	47	Traumatic	Failed or contraindicated	Retrospective series (low)
Ahlhelm et al. (2013) [26]	7	Traumatic, spontaneous, iatrogenic	Failed or contraindicated	Retrospective series (low)
Yin et al. (2011) [28]	33	Traumatic, spontaneous	Failed or contraindicated	Retrospective series (low)
Edgell et al. (2005) [46]	7	Spontaneous	Failed or contraindicated	Retrospective series (low)
Kansagra et al. (2014) [64]	2	Traumatic, iatrogenic	Unknown	Retrospective series (low)
Cohen et al. (2012) [27]	23	Traumatic	Failed or contraindicated	Retrospective series (low)
DiCocco et al. (2011) [32]	50	Traumatic	Failed or contraindicated	Retrospective series (low)
Ohta et al. (2011) [30]	43	Traumatic, spontaneous	Failed or not attempted	Retrospective series (low)
Chandra et al. (2007) [42]	1	Spontaneous	Failed	Retrospective series (low)
Edwards et al. (2007) [41]	4	Traumatic	Failed	Retrospective series (low)

specialties represented in the selected literature. The procedures were performed for traumatic, spontaneous, and iatrogenic dissections. Most descriptions report symptomatic improvement with a low periprocedural complication rate. While follow-up data is limited, most series report a low incidence of early stent thrombosis.

The indications for stent placement continue to be poorly defined. Thirty-one of the selected series report failure or contraindication to medical management as the primary reason for endovascular management. However, the type and duration of attempted medical therapy remain unclear in most reports. Twelve studies did not attempt medical management at all prior to intervention. It remains undefined what truly constitutes failure of medical therapy.

Several large series have demonstrated that stenting appears to be a safe procedure for selected cases of carotid dissection. A large retrospective review in 2013 evaluated the outcome of 53 self-expanding stents placed for symptomatic traumatic carotid dissection. The authors found that 6.4 % of patients had transient postoperative symptoms, 2.1 % had luminal narrowing or a new aneurysm on follow up, and 2 % had asymptomatic stent occlusion on follow up. In all, 4.3 % of patients required some form of reintervention. Overall, they concluded that carotid stenting for traumatic cervical carotid dissection was safe and effective [23]. Similarly, a large single-center experience with stenting for traumatic carotid dissection in 2012 concluded that stenting appeared to be safe in selected patients. Twenty-three patients underwent stenting; 70 % had improved symptoms after the procedure and 26 % had stable symptoms. There was one death in their study from unrelated traumatic injuries. All stents were patent at follow up [27]. A 2011 retrospective review examining stents placed for both traumatic and spontaneous carotid dissection reported no postoperative stenosis or major cardiovascular events in their 33 patients. One patient did have a recurrent TIA after the procedure, but there was no permanent neurologic deficit. The authors' conclusion was that stenting is a safe treatment option in selected cases of carotid dissection [28].

While there are no studies that compare open repair to endovascular repair, there are some retrospective studies that evaluate anticoagulation alone versus endovascular management. Unfortunately, many of the studies have a limited number of patients, making drawing conclusions difficult. For example, a 2007 single-center experience with spontaneous carotid dissection included 12 patients, only one of which underwent revascularization. That patient underwent bilateral carotid stent placement, but unfortunately suffered postoperative intracranial hemorrhage. The authors concluded that anticoagulation was safer than stent placement as none of the patients who were anticoagulated suffered any complications [42]. A 2005 study evaluated 46 patients with blunt cerebrovascular injury, 23 of whom underwent stent placement. Of the 23 stent patients, 4 had postoperative strokes and 1 developed a subclavian artery dissection. Eight patients with available follow-up had post-stent occlusion (45 % compared to 5 % carotid occlusion in the anticoagulation group). The authors concluded that the risks of carotid artery stenting in this setting outweigh the benefits [47]. Finally, a large series analyzing 222 trauma patients with blunt cerebrovascular injury included 50 patients treated with carotid stenting. At follow up, the authors saw no difference in complications or patency between the anticoagulation and stent group, claiming stents were safe but no better than anticoagulation [32].

There have been two systematic reviews published regarding the role of endovascular management in carotid artery dissection. A 2008 systematic review which evaluated 13 studies and 63 stents found no mortalities, 100 % patency and 11 % stroke rate at a 16 month mean follow up period [65]. In 2013, a systematic review which included 23 studies and 201 patients tabulated a 4 % rate of perioperative cardiovascular adverse events, as well as a 2.1 % rate of recurrent TIA. The authors concluded stents are safe for use in carotid dissection [66].

Multiple review articles and management guidelines have also been published regarding the appropriate management of traumatic carotid dissection and role for

endovascular management (Table 32.4). The consensus of all of these articles is that anticoagulation should remain as first line therapy. If patients fail anticoagulation or are not candidates for anticoagulation, endovascular management remains a safe therapy. It remains undecided what constitutes a true failure of medical therapy [67–71].

Recommendations

Carotid artery dissection is an uncommon, but potentially serious condition that can lead to significant morbidity and mortality. They can occur spontaneously, or as the result of trauma or iatrogenic injury. The first line treatment for carotid artery dissection remains anticoagulation. However, in patients with continued symptoms or those in whom anticoagulation is contraindicated, revascularization may be warranted. Both open surgical repair and endovascular stent placement have been described. Both techniques have been reported to have good outcomes (evidence quality weak). Modern publications have focused mainly on endovascular

Table 32.4 Review articles regarding the management of carotid artery dissection

Study	Title	Recommendation	Type of study (grade of evidence)
Fusco and Harrigan (2011) [69]	Cerebrovascular dissections: a review. Part II: blunt cerebrovascular injury	Anticoagulation as primary treatment, endovascular therapy for refractory patients. Surgery only for patients who are not candidates for endovascular therapy	Review article based on low grade evidence
Bromberg et al. (2010) [67]	Blunt cerebrovascular injury practice management guidelines: the Eastern Association for the Surgery of Trauma	Grade I and II injuries should be anticoagulated. Grade III and higher, or symptomatic patients should be considered for an intervention	Review article based on low grade evidence
Moulakakis et al. (2010) [70]	An update of the role of endovascular repair in blunt carotid artery trauma	Anticoagulation as primary treatment, endovascular therapy for refractory patients. Surgery only for patients who are not candidates for endovascular therapy	Review article based on low grade evidence
DuBose et al. (2008) [68]	Endovascular stenting for the treatment of traumatic internal carotid injuries	Early results on endovascular therapies are encouraging, but data is limited	Review article based on low grade evidence
Redekop (2008) [71]	Extracranial carotid and vertebral artery dissection: a review	Anticoagulation as primary treatment, consider stent placement in symptomatic patients or acute hemodynamic instability	Review article based on low grade evidence

techniques, which have been shown to have minimal postoperative complications and good patency rates at follow up (evidence quality weak). Based on the available data, we make a weak recommendation for endovascular carotid stent placement in symptomatic carotid artery dissection following failure of attempted medical therapy.

Personal View of the Data

There is ample data supporting anticoagulation as first-line therapy in patients with carotid artery dissection, but no clear consensus duration of treatment or what constitutes failure. Open repair has become increasingly rare. There are no randomized trials and all of the data for either open surgical or endovascular management is of weak quality. However, data supports both types of surgical intervention as safe and effective in appropriately selected patients. Due to the relatively rare incidence of carotid artery dissection and good reported outcomes with both techniques, there is unlikely to be a head-to-head trial between open repair and endovascular stent placement. Future endeavors should continue to define what constitutes true failure of medical therapy, as well as identifying patients who may be considered for prophylactic stenting while still asymptomatic.

Recommendations

- Anticoagulation remains the first-line therapy for carotid artery dissection (**evidence quality moderate, strong recommendation**)
- For patients who fail or are not candidates for anticoagulation, both open surgical repair and endovascular stent placement represent equally safe and effective management (**evidence quality low, weak recommendation**)

References

1. Bogousslavsky J, Despland PA, Regli F. Spontaneous carotid dissection with acute stroke. Arch Neurol. 1987;44(2):137–40.
2. Bogousslavsky J, Regli F. Ischemic stroke in adults younger than 30 years of age. Cause and prognosis. Arch Neurol. 1987;44(5):479–82.
3. Biffl WL, Moore EE, Offner PJ, et al. Optimizing screening for blunt cerebrovascular injuries. Am J Surg. 1999;178(6):517–22.
4. Lyrer P, Engelter S. Antithrombotic drugs for carotid artery dissection. Cochrane Database Syst Rev. 2003;(3):CD000255.
5. Sarikaya H, da Costa BR, Baumgartner RW, et al. Antiplatelets versus anticoagulants for the treatment of cervical artery dissection: Bayesian meta-analysis. PLoS One. 2013;8(9):e72697.
6. Kennedy F, Lanfranconi S, Hicks C, et al. Antiplatelets vs anticoagulation for dissection: CADISS nonrandomized arm and meta-analysis. Neurology. 2012;79(7):686–9.

7. Alimi Y, Di Mauro P, Tomachot L, et al. Bilateral dissection of the internal carotid artery at the base of the skull due to blunt trauma: incidence and severity. Ann Vasc Surg. 1998;12(6):557–65.
8. Koennecke H, Seyfert S. Mydriatic pupil as the presenting sign of common carotid artery dissection. Stroke J Cereb Circ. 1998;29(12):2653–5.
9. Vishteh AG, Marciano FF, David CA, Schievink WI, Zabramski JM, Spetzler RF. Long-term graft patency rates and clinical outcomes after revascularization for symptomatic traumatic internal carotid artery dissection. Neurosurgery. 1998;43(4):761–7; discussion 767–8.
10. Humphrey PW, Keller MP, Spadone DP, Silver D. Spontaneous common carotid artery dissection. J Vasc Surg. 1993;18(1):95–9.
11. Waespe W, Niesper J, Imhof HG, Valavanis A. Lower cranial nerve palsies due to internal carotid dissection. Stroke J Cereb Circ. 1988;19(12):1561–4.
12. Miyamoto S, Kikuchi H, Karasawa J, Kuriyama Y. Surgical treatment for spontaneous carotid dissection with impending stroke. Case report. J Neurosurg. 1984;61(2):382–6.
13. Dragon R, Saranchak H, Lakin P, Strauch G. Blunt injuries to the carotid and vertebral arteries. Am J Surg. 1981;141(4):497–500.
14. Aspalter M, Linni K, Domenig CM, Mader N, Klupp N, Holzenbein TJ. Successful repair of bilateral common carotid artery dissections from hanging. Ann Vasc Surg. 2013;27(8):1186.e7–15.
15. Takeuchi S, Wada K, Sakakibara F, Mori K. A surgical case of paraclinoid carotid aneurysm associated with ipsilateral cervical internal carotid artery dissection. Neurol India. 2012;60(5):517–9.
16. Geraldes R, Batista P, Pedro LM, Fernandes A, Melo TP. Takayasu arteritis presenting with internal carotid artery dissection. Cerebrovasc Dis. 2012;33(4):408–9.
17. Cuff RF, Thomas JH. Pediatric blunt carotid injury from low-impact trauma: a case report and review of the literature. J Trauma. 2005;58(3):620–3.
18. Findlay JM, Ashforth R, Dean N. "Malignant" carotid artery dissection. Can J Neurol Sci Le journal canadien des sciences neurologiques. 2002;29(4):378–85.
19. Muller BT, Luther B, Hort W, Neumann-Haefelin T, Aulich A, Sandmann W. Surgical treatment of 50 carotid dissections: indications and results. J Vasc Surg. 2000;31(5):980–8.
20. Cafasso D, Meadows JM, Wolfe SQ, Katras T, Kellicut DC, Golarz SR. Endovascular treatment of bilateral carotid artery pseudoaneurysms after blunt carotid injury. Ann Vascu Surg. 2014;28(1):263.e211–6.
21. Asif KS, Lazzaro MA, Teleb MS, Fitzsimmons BF, Lynch J, Zaidat O. Endovascular reconstruction for progressively worsening carotid artery dissection. J Neurointerv Surg. 2015;7:32–9.
22. To CY, Badr Y, Richards B. Treatment of acute cervical internal carotid artery dissection using the Solitaire FR revascularization device. J Neurointervent Surg. 2013;5(6):e50.
23. Seth R, Obuchowski AM, Zoarski GH. Endovascular repair of traumatic cervical internal carotid artery injuries: a safe and effective treatment option. AJNR Am J Neuroradiol. 2013;34(6):1219–26.
24. Loret JE, Francois P, Papagiannaki C, Cottier JP, Terrier LM, Zemmoura I. Internal carotid artery dissection after anterior cervical disc replacement: first case report and literature review of vascular complications of the approach. Eur J Orthop Surg Traumatol Orthop Traumatol. 2013;23 Suppl 1:S107–10.
25. Geng L, Zha C, Liu H, Xu J, Xiang Y, Zou Z. Acute carotid artery dissection treated with stenting and hematoma aspiration guided by ultrasonography. J Clin Ultrasound JCU. 2013;41(8):509–13.
26. Ahlhelm F, Benz RM, Ulmer S, Lyrer P, Stippich C, Engelter S. Endovascular treatment of cervical artery dissection: ten case reports and review of the literature. Interven Neurol. 2013;1(3–4):143–50.
27. Cohen JE, Gomori JM, Itshayek E, et al. Single-center experience on endovascular reconstruction of traumatic internal carotid artery dissections. J Trauma Acute Care Surg. 2012;72(1):216–21.

28. Yin Q, Li Y, Fan X, et al. Feasibility and safety of stenting for symptomatic carotid arterial dissection. Cerebrovasc Dis. 2011;32 Suppl 1:11–5.
29. Schirmer CM, Atalay B, Malek AM. Endovascular recanalization of symptomatic flow-limiting cervical carotid dissection in an isolated hemisphere. Neurosurg Focus. 2011;30(6):E16.
30. Ohta H, Natarajan SK, Hauck EF, et al. Endovascular stent therapy for extracranial and intracranial carotid artery dissection: single-center experience. J Neurosurg. 2011;115(1): 91–100.
31. Fukunaga N, Hanaoka M, Sato K. Asymptomatic common carotid artery dissection caused by blunt injury. Emerg Med J EMJ. 2011;28(1):50.
32. DiCocco JM, Fabian TC, Emmett KP, et al. Optimal outcomes for patients with blunt cerebrovascular injury (BCVI): tailoring treatment to the lesion. J Am Coll Surg. 2011;212(4):549–57; discussion 557–9.
33. Stella N, Palombo G, Filippi F, Fantozzi C, Taurino M. Endovascular treatment of common carotid artery dissection via the superficial temporal artery. J Endovasc Ther Off J Int Soc Endovasc Spec. 2010;17(4):569–73.
34. Keilani ZM, Berne JD, Agko M. Bilateral internal carotid and vertebral artery dissection after a horse-riding injury. J Vasc Surg. 2010;52(4):1052–7.
35. Jeon P, Kim BM, Kim DI, et al. Emergent self-expanding stent placement for acute intracranial or extracranial internal carotid artery dissection with significant hemodynamic insufficiency. AJNR Am J Neuroradiol. 2010;31(8):1529–32.
36. Sharma GK, Deshmukh VR, Albuquerque FC, Wolf TR, McDougall CG. Resolution of mydriatic pupil after angioplasty and stenting of cervical internal carotid artery dissection: case report. Neurosurgery. 2009;64(3):E562–3; discussion E563.
37. Schulte S, Donas KP, Pitoulias GA, Horsch S. Endovascular treatment of iatrogenic and traumatic carotid artery dissection. Cardiovasc Intervent Radiol. 2008;31(5):870–4.
38. Fuse T, Ichihasi T, Matuo N. Asymptomatic carotid artery dissection caused by blunt trauma. Neurol Med Chir. 2008;48(1):22–5.
39. Fava M, Meneses L, Loyola S, et al. Carotid artery dissection: endovascular treatment. Report of 12 patients. Catheter Cardiovasc Interven Off J Soc Cardiac Angiogr Interven. 2008;71(5): 694–700.
40. Nakagawa N, Akai F, Fukawa N, et al. Endovascular stent placement of cervical internal carotid artery dissection related to a seat-belt injury: a case report. Minim Invasive Neurosurg MIN. 2007;50(2):115–9.
41. Edwards NM, Fabian TC, Claridge JA, Timmons SD, Fischer PE, Croce MA. Antithrombotic therapy and endovascular stents are effective treatment for blunt carotid injuries: results from longterm followup. J Am Coll Surg. 2007;204(5):1007–13; discussion 1014–5.
42. Chandra A, Suliman A, Angle N. Spontaneous dissection of the carotid and vertebral arteries: the 10-year UCSD experience. Ann Vasc Surg. 2007;21(2):178–85.
43. Chokyu I, Tsumoto T, Miyamoto T, Yamaga H, Terada T, Itakura T. Traumatic bilateral common carotid artery dissection due to strangulation. A case report. Interven Neuroradiol J Perither Neuroradiol Surg Proc Relat Neurosci. 2006;12(2):149–54.
44. Vazquez Rodriguez C, Lemaire V, Renard F, De Keuleneer R. Primary stenting for the acute treatment of carotid artery dissection. Eur J Vascu Endovasc Surg Off J Eur Soc Vascu Surg. 2005;29(4):350–2.
45. Lin PH, Bush RL, Lumsden AB. Endovascular treatment for symptomatic carotid artery dissection. J Vasc Surg. 2005;41(3):555.
46. Edgell RC, Abou-Chebl A, Yadav JS. Endovascular management of spontaneous carotid artery dissection. J Vasc Surg. 2005;42(5):854–60; discussion 860.
47. Cothren CC, Moore EE, Ray Jr CE, et al. Carotid artery stents for blunt cerebrovascular injury: risks exceed benefits. Arch Surg. 2005;140(5):480–5; discussion 485–6.
48. Cohen JE, Ben-Hur T, Rajz G, Umansky F, Gomori JM. Endovascular stent-assisted angioplasty in the management of traumatic internal carotid artery dissections. Stroke J Cereb Circ. 2005;36(4):e45–7.

49. Cohen JE, Ben-Hur T, Gomori JM, Umansky F, Lylyk P, Rajz G. Stent-assisted arterial reconstruction of traumatic extracranial carotid dissections. Neurol Res. 2005;27 Suppl 1:S73–8.
50. Abboud H, Houdart E, Meseguer E, Amarenco P. Stent assisted endovascular thrombolysis of internal carotid artery dissection. J Neurol Neurosurg Psychiatry. 2005;76(2):292–3.
51. Biggs KL, Chiou AC, Hagino RT, Klucznik RP. Endovascular repair of a spontaneous carotid artery dissection with carotid stent and coils. J Vasc Surg. 2004;40(1):170–3.
52. Tseng A, Ramaiah V, Rodriguez-Lopez JA, et al. Emergent endovascular treatment of a spontaneous internal carotid artery dissection with pseudoaneurysm. J Endovasc Ther Off J Int Soc Endovasc Spec. 2003;10(3):643–6.
53. Sbarigia E, Battocchio C, Panico MA, Zaccagnini D, Salvatori FM, Argentino C. Endovascular management of acute carotid artery dissection with a waxing and waning neurological deficit. J Endovasc Ther Off J Int Soc Endovasc Spec. 2003;10(1):45–8.
54. Cohen JE, Leker RR, Gotkine M, Gomori M, Ben-Hur T. Emergent stenting to treat patients with carotid artery dissection: clinically and radiologically directed therapeutic decision making. Stroke J Cereb Circ. 2003;34(12):e254–7.
55. Bassi P, Lattuada P, Gomitoni A. Cervical cerebral artery dissection: a multicenter prospective study (preliminary report). Neurol Sci Off J Italian Neurol Soc Italian Soc Clin Neurophys. 2003;24 Suppl 1:S4–7.
56. Lee DH, Hur SH, Kim HG, Jung SM, Ryu DS, Park MS. Treatment of internal carotid artery dissections with endovascular stent placement: report of two cases. Korean J Radiol Off J Korean Radiol Soc. 2001;2(1):52–6.
57. Saito R, Ezura M, Takahashi A, Yoshimoto T. Combined neuroendovascular stenting and coil embolization for cervical carotid artery dissection causing symptomatic mass effect. Surg Neurol. 2000;53(4):318–22.
58. Malek AM, Higashida RT, Phatouros CC, et al. Endovascular management of extracranial carotid artery dissection achieved using stent angioplasty. AJNR Am J Neuroradiol. 2000;21(7):1280–92.
59. Malek AM, Higashida RT, Halbach VV, et al. Patient presentation, angiographic features, and treatment of strangulation-induced bilateral dissection of the cervical internal carotid artery. Report of three cases. J Neurosurg. 2000;92(3):481–7.
60. Kerby JD, May AK, Gomez CR, Rue 3rd LW. Treatment of bilateral blunt carotid injury using percutaneous angioplasty and stenting: case report and review of the literature. J Trauma. 2000;49(4):784–7.
61. Liu AY, Paulsen RD, Marcellus ML, Steinberg GK, Marks MP. Long-term outcomes after carotid stent placement treatment of carotid artery dissection. Neurosurgery. 1999;45(6):1368–73; discussion 1373–4.
62. Matsuura JH, Rosenthal D, Jerius H, Clark MD, Owens DS. Traumatic carotid artery dissection and pseudoaneurysm treated with endovascular coils and stent. J Endovasc Surg Off J Int Soc Endovasc Surg. 1997;4(4):339–43.
63. Duke BJ, Ryu RK, Coldwell DM, Brega KE. Treatment of blunt injury to the carotid artery by using endovascular stents: an early experience. J Neurosurg. 1997;87(6):825–9.
64. Kansagra AP, Cooke DL, English JD, et al. Current trends in endovascular management of traumatic cerebrovascular injury. J Neurointerven Surg. 2014;6(1):47–50.
65. Donas KP, Mayer D, Guber I, Baumgartner R, Genoni M, Lachat M. Endovascular repair of extracranial carotid artery dissection: current status and level of evidence. J Vasc Interven Radiol JVIR. 2008;19(12):1693–8.
66. Xianjun H, Zhiming Z. A systematic review of endovascular management of internal carotid artery dissections. Interven Neurol. 2013;1(3–4):164–70.
67. Bromberg WJ, Collier BC, Diebel LN, et al. Blunt cerebrovascular injury practice management guidelines: the Eastern Association for the Surgery of Trauma. J Trauma. 2010;68(2):471–7.
68. DuBose J, Recinos G, Teixeira PG, Inaba K, Demetriades D. Endovascular stenting for the treatment of traumatic internal carotid injuries: expanding experience. J Trauma. 2008;65(6):1561–6.

69. Fusco MR, Harrigan MR. Cerebrovascular dissections: a review. Part II: blunt cerebrovascular injury. Neurosurgery. 2011;68(2):517–30; discussion 530.
70. Moulakakis KG, Mylonas S, Avgerinos E, Kotsis T, Liapis CD. An update of the role of endovascular repair in blunt carotid artery trauma. Eur J Vasc Endovasc Surg Off J Eur Soc Vascu Surg. 2010;40(3):312–9.
71. Redekop GJ. Extracranial carotid and vertebral artery dissection: a review. Can J Neurol Sci Le journal canadien des sciences neurologiques. 2008;35(2):146–52.