Review began 07/27/2021

Review ended 09/03/2021

Published 09/14/2021

© Copyright 2021

Al Babbain et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

The Relationship Between Cerebrovascular Injuries and Craniomaxillofacial Fractures: Findings From a Tertiary Hospital in Saudi Arabia

Ibrahim Al Babbain¹, Mohammed Abdullah M Alsahly², Ahmed Bandar A Aba Alkhail², Jehad T. Almutib³, Rakan Ahmed F. Al Otaibi³, Abdullah Saad H. Alsalamah⁴, Yahya M. Asseri⁵, Ahmed O. Ahmed⁵

1. Department of General Surgery, King Abdulaziz Medical City, Riyadh, SAU 2. Medicine, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, SAU 3. Medicine, College of Medicine, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, SAU 4. Surgery, College of Medicine, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, SAU 5. Radiology, King Abdulaziz Medical City, Riyadh, SAU

Corresponding author: Mohammed Abdullah M Alsahly, dralsahlymohammed@gmail.com

Abstract

Background and objective

Blunt cerebrovascular injuries (BCVIs) can lead to serious outcomes, particularly because they are difficult to detect in the acute phase. There are studies that have described the association between cerebrovascular injuries and craniomaxillofacial (CMF) fractures; however, no such study has been conducted among a Saudi population. In light of this, we conducted this study to evaluate the correlation between BCVI and CMF fractures among the local population in Saudi Arabia. In addition, the most common types of fractures associated with BCVI were identified.

Methods

This retrospective cohort study was conducted at the King Abdulaziz Medical City, a tertiary hospital in Riyadh, Saudi Arabia. All eligible patients with CMF fractures who were hospitalized at the King Abdulaziz Medical City were included. Consecutive patients were screened; no sampling or randomization was required. Patients with penetrating or avulsive mechanisms of injury were excluded.

Results

Out of a total of 1,560 patients included in the study, 1,537 (98.5%) had CMF fractures, while 23 (1.5%) had BCVIs. None of the patients with CMF fractures had BCVIs. Among the patients with BCVIs, 12 (52.2%) were men and 11 (47.8%) were women. The mean age of these patients was 46.91 ± 17.04 years. Among patients with CMF fractures, 1,071 (69.7%) were men and 466 (30.3%) were women. Their mean age was 23.93 ± 17.36 years.

Conclusion

The study did not identify any correlation between BCVI and CMF fractures; however, further studies with larger samples across multiple centers are needed to validate our findings and gain deeper insight into the relationship between BCVI and CMF fractures.

Categories: Trauma

Keywords: blunt cerebrovascular injury, craniomaxillofacial fracture, skull fractures, facial fractures, internal carotid artery, vertebral artery

Introduction

Blunt trauma can cause vascular injury to the vertebral and internal carotid arteries. Blunt cerebrovascular injuries (BCVIs) secondary to craniomaxillofacial (CMF) fractures are usually difficult to detect in an acute setting and hence may lead to a delay in diagnosis [1-3]. Although BCVI is considered rare, accounting for only 1% of all blunt trauma cases, it has an estimated stroke-related mortality rate of 21% [3-6]. Early intervention plays a major role in reducing cerebrovascular insult, from 20% to 9.6% as per some studies [2,4,7]. Despite the devastating consequences of BCVI, controversy still exists with respect to identifying the population at risk of this injury [2,8-9]. The association between BCVI and CMF fractures has been demonstrated in several previous studies [2,10-12]. Studies about the patterns of CMF fractures have shown varying results due to age as well as social and ethnic diversity among the study populations [13-15]. Hence, we believe there is a need to continually update the fracture patterns of injury. The aim of this study was to update the information on fracture patterns in the capital region of Riyadh, Saudi Arabia, and to determine whether there is an association between CMF fractures and BCVI.

How to cite this article

Al Babbain I, Abdullah M Alsahly M, A Aba Alkhail A, et al. (September 14, 2021) The Relationship Between Cerebrovascular Injuries and Craniomaxillofacial Fractures: Findings From a Tertiary Hospital in Saudi Arabia. Cureus 13(9): e17959. DOI 10.7759/cureus.17959

Materials And Methods

Study design and settings

This was a retrospective cohort study conducted to assess the relationship between BCVI and CMF fractures among hospitalized trauma patients at the King Abdulaziz Medical City, Ministry of National Guard Health Affairs, Riyadh, the Kingdom of Saudi Arabia. With a bed capacity of 1,501, the King Abdulaziz Medical City is one of the largest tertiary care centers in the Kingdom. It serves the National Guard personnel and their families.

Study population

The study included all consecutive patients with CMF fractures and patients with BCVI who were admitted to the King Abdulaziz Medical City between January 2016 and December 2020. Patients with penetrative injuries and avulsion as the mechanism of injury as well as those without a CT scan for review were excluded.

Data collection

Ethical approval and data were provided by the King Abdullah International Medical Research Center. Data were extracted from the BESTCare system, the digital hospital information system used at the King Abdulaziz Medical City, and then entered into and coded using Microsoft Excel. The collected data included patient demographics such as age, sex, type of fracture, and type of BCVI, which was determined by two radiologists after reviewing patients' CT scans. BCVI was classified into five grades based on the Denver scale. The type of fracture data provided was as follows: upper facial (frontal bone, frontal sinus, orbital roof), midfacial (Le Fort I-III, naso-orbito-ethmoidal, zygomatic, orbital other than the roof, maxillary, nasal), lower facial, basilar (sphenoid, temporal, petrous, occipital, unspecified), combined facial fracture, combined skull fracture, and other fractures.

Statistical analysis

Statistical analysis was performed using SPSS Statistics version 23 (IBM Corp., Armonk, NY). Categorical variables are presented as frequencies and percentages. Numerical variables are calculated as means and standard deviations. The Chi-square test was used to test for the presence of an association between categorical variables. The independent t-test was also used to test for the association. A p-value less than 0.05 was considered statistically significant.

Results

A total of 1,560 patients were included in the study. Figure 1 shows the diagnosis summary of the patients; 1,537 (98.5%) patients had CMF fractures, while 23 (1.5%) had a BCVI. None of the patients with CMF fractures had a BCVI.

Table 1 presents the sociodemographic characteristics of the included patients. Among the patients with BCVI, 12 (52.2%) were men and 11 (47.8%) were women, with an overall mean age of 46.91 ± 17.04 years. Among the patients with CMF fractures, 1,071 (69.7%) were men and 466 (30.3%) were women, with an overall mean age of 23.94 ± 17.40 years.

Patient characteristics		
Blunt cerebrovascular injury (BCVI) (n=23)	N	%
Sex		
Male	12	52.2
Female	11	47.8
Age (years)		
Mean	46.91	
Standard deviation	17.04	
Craniomaxillofacial fracture (n=1,537)	N	%
Sex		
Male	1,071	69.7
Female	466	30.3
Age (years)		
Mean	23.94	
Standard deviation	17.4	

TABLE 1: Sociodemographic characteristics of patients (n=1,560)

Table 2 displays the CMF fracture profiles. Among the 31 patients with upper third facial fractures, nine (0.59%) had frontal bone fractures, seven (0.45%) had frontal sinus fractures, and 15 (0.98%) had orbital roof fractures. Among the 777 patients with midfacial fractures, seven (0.45%) had Le Fort I fractures, three (0.2%) had Le Fort II fractures, two (0.13%) had Le Fort III fractures, 19 (1.24%) had naso-orbito-ethmoidal fractures, 68 (4.42%) had midfacial zygomatic fractures, 62 (4%) had an orbital other than the roof fracture, 47 (3.06%) had a maxillary fracture, and 595 (38.71%) had a nasal fracture. As for the basilar skull fracture types, one (0.07%) patient had a sphenoid fracture, 36 (2.3%) had temporal fractures, 10 (0.7%) had basilar occipital fractures, and 19 (1.2%) had unspecified skull fractures. Of all the patients, 273 (17.8%) had unspecified facial and skull fractures.

Location of fracture	N	%
Upper facial fracture (n=31)		
Frontal bone	9	0.59
Frontal sinus	7	0.45
Orbital roof	15	0.98
Midfacial fractures (n=803)		
Le Fort I	7	0.45
Le Fort II	3	0.2
Le Fort III	2	0.13
Naso-orbito-ethmoidal	19	1.24
Zygomatic	68	4.42
Orbital other than the roof	62	4
Maxillary	47	3.06
Nasal	595	38.71
Basilar skull fractures (n=61; however, the total adds up to 66)		
Sphenoid	1	0.07
Temporal	36	2.3
Basilar of occipital	10	0.7
Unspecified	19	1.2
Facial and skull unspecified	273	17.8
Other (n=136)		
Teeth	136	8.8

TABLE 2: Summary of the various types of craniomaxillofacial fracture

Figure 2 shows the types of BCVI among these patients. Two patients (8.7%) had type 1 BCVI, 19 (82.6%) had type 2, one (4.3%) had type 3, and five (21.7%) patients had type 4.

Figure 3 presents the affected arteries among patients with BCVI. The carotid artery was affected in 19 (82.6%) patients, the vertebral artery was affected in two (8.7%), and both the carotid and vertebral artery were affected in two (8.7%) patients.

FIGURE 2: Blunt cerebrovascular injury types

FIGURE 3: Affected arteries in patients with blunt cerebrovascular injuries

Figure 4 illustrates the fracture types in patients with CMF fractures. Thirty-one patients (2%) had upper third facial fractures, 777 (50.6%) had midfacial fractures, 135 (8.8%) had lower face/mandible fractures, 10 (0.7%) had combined facial fractures, 61 (4%) had basilar skull fractures, 18 (1.2%) had combined skull fractures, and 120 (7.8%) had other skull fractures. Among the patients with CMF fractures, 176 (11.4%) also had tooth fractures.

Figure 5 shows the types of upper facial fractures detected in the study. Among the 31 patients with upper third facial fractures, nine (0.59%) had frontal bone fractures, seven (0.45%) had frontal sinus fractures, and 15 (0.98%) had orbital roof fractures.

FIGURE 4: Craniomaxillofacial fracture types

FIGURE 5: Upper facial fracture types

Figure 6 presents the midfacial fracture types detected in the study participants. Among the 777 patients with midfacial fractures, seven (0.45%) had a Le Fort I fracture, three (0.2%) had a Le Fort II fracture, two (0.13%) had a Le Fort III fracture, 19 (1.24%) had a naso-orbito-ethmoidal fracture, 68 (4.42%) had a midfacial zygomatic fracture, 62 (4%) had orbital other than the roof fracture, 47 (3.06%) had a maxillary fracture, and 595 (38.71%) had a nasal fracture.

Figure 7 shows the basilar skull fracture types. One (0.07%) patient had a sphenoid fracture, 36 (2.3%) had a temporal fracture, 10 (0.7%) had a basilar occipital fracture, and 19 (1.2%) had an unspecified skull fracture.

FIGURE 6: Midfacial fractures

FIGURE 7: Basilar skull fractures

Table 3 shows the factors associated with BCVI. Age was significantly associated with BCVI ($p < 0.001$). Patients with BCVI had significantly higher mean age than those without BCVI (46.91 ± 17.04 vs. 23.94 ± 17.40 years, respectively). Sex was not significantly associated with BCVI.

Factor	Blunt cerebrovascular injury		P-value
	No	Yes	
Sex, n (%)			
Male	1,071 (98.9%)	12 (1.1%)	0.07
Female	466 (97.7%)	11 (2.3%)	
Age (years), mean + SD	23.94 + 17.40	46.91 + 17.04	<0.001*

TABLE 3: Factors associated with blunt cerebrovascular injury

*Significant at level <0.05

SD: standard deviation

Discussion

The findings of epidemiological studies are largely dependent on the demographics of the study population, including socioeconomic status, geographic location, and period of the study [16]. Nevertheless, the results of our research align with those of many local and international studies. The mean age of the participants with CMF fractures in our study was 23.94 ± 17.40 years, which is similar to the average of 25.75 ± 15.5 years found in another study [17]. Upper facial fractures were the least prevalent type of CMF fractures, a finding corroborated by two other studies to date [18,19].

Furthermore, midfacial fractures were found to be the most common type of CMF fractures, accounting for more than 50.6% of all CMF fractures. This finding is supported by an Austrian study, which found that midfacial fractures were the most common facial bone fractures, accounting for more than 71.5% of their sample of 7,061 patients with bone fractures [14]. Among midfacial fractures, nasal bone fractures were the most common type, followed by zygomatic, orbital (excluding the roof), and maxillary fractures, which are comparable to findings of a 2006 study in which zygomatic fractures and nasal fractures were the most common subtypes, accounting for 24% and 23% of all midfacial fractures, respectively [15,20]. However, another study found zygoma to be the most common midfacial fracture, followed by the maxilla and nasal fractures [21]. Furthermore, a retrospective study of 2,969 patients from 12 trauma centers in Ontario, Canada, revealed that the most commonly occurring fractures were found in the maxilla and orbital regions, followed by the zygoma and nasal bone [22]; thus, although midfacial fractures are the most common type, there is variation between various midfacial fracture subtypes.

Regarding the Le Fort classification of midfacial fractures, in our study, Le Fort I was the most common type, followed by Le Fort II and III, respectively, which is similar to the results of another study that found the

most common fracture type to be Le Fort I followed by Le Fort II [23]. In our study, basilar fractures accounted for 4% of all CMF fractures and 30% of all skull fractures. The temporal bone fracture was the most common basilar fracture, accounting for 55% of these types of fractures, followed by the basilar part of the occipital bone (15%) and the sphenoid bone (2%). These results are similar to those of a study that found prevalence rates of 47%, 45%, and 37% for these three fractures, respectively [24].

As the practice of trauma surgery has continued to evolve, awareness of BCVI among clinicians has increased. In this study, we investigated the incidence rate of BCVI among patients with CMF fractures in our center and found 23 incidents of BCVI, none of whom had CMF fractures. No local data regarding the relationship between BCVI and CMF fractures is available in the literature. However, several studies support our findings [2,25,26], while some others do not. A systematic review identified 410 BCVI cases among 90,968 blunt trauma admissions with CMF fractures, constituting an overall incidence of 0.45% [18]. The mean age of BCVI patients in our study was 46.91 ± 17.04 years, similar to that in Weber et al.'s study (46 ± 19 years) [25]. In our study, 52.2% of BCVI patients were male, whereas the proportion of males with BCVI reported in other studies ranged from 57.8-65.2% [2,9,27,28].

Grade 1 was the most frequently reported injury grade in a study conducted by Malhotra et al. [29]. According to Stein et al., both grades 1 and 2 were reported in similar numbers and comprised the most common BCVI grades, followed by grades 4, 3, and 5, respectively [2]. However, the most commonly reported BCVI grade in our study was grade 2, followed by grades 4, 3, 1, and 5.

There is inconsistency in the literature regarding the injured vessels in the BCVI. Berne et al. and Savoie et al. have reported more vertebral artery injuries than carotid artery injuries [9,27]. Nevertheless, the findings of our study align with those of Weber et al. and Jones et al., who found a preponderance of carotid artery injuries [25,28].

Conclusions

Our study examined the prevalence of CMF fractures in a tertiary hospital in Riyadh, Saudi Arabia. We found that midfacial fractures were the most common type, especially nasal fractures, and we found no incidence of BCVI among patients with CMF fractures. We also found that the mean age of the patients with CMF fractures was 23.94 ± 17.40 years, while it was 46.91 ± 17.04 years for patients with BCVI. More local studies need to be conducted to further investigate the types of CMF fractures and the incidence of BCVI among them.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Institutional Review Board of the King Abdullah International Medical Research Center issued approval NRC21R/110/03. The study was approved by the Institutional Review Board of the King Abdullah International Medical Research Center, Ministry of National Guard-Health Affairs, Riyadh, the Kingdom of Saudi Arabia (approval number NRC21R/110/03). Patient confidentiality was ensured, and the patients' data were collected and used by the research team only. Serial numbers were used instead of medical record numbers to ensure anonymity. Due to the retrospective nature of the study, and the use of anonymized patient data, the requirement for informed consent was waived. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

- Berne JD, Norwood SH, McAuley CE, Vallina VL, Creath RG, McLarty J: The high morbidity of blunt cerebrovascular injury in an unscreened population: more evidence of the need for mandatory screening protocols. *J Am Coll Surg*. 2001, 192:314-21. [10.1016/s1072-7515\(01\)00772-4](https://doi.org/10.1016/s1072-7515(01)00772-4)
- Stein DM, Boswell S, Sliker CW, Lui FY, Scalea TM: Blunt cerebrovascular injuries: does treatment always matter?. *J Trauma*. 2009, 66:132-43. [10.1097/TA.0b013e318142d146](https://doi.org/10.1097/TA.0b013e318142d146)
- Biffi WL, Moore EE, Offner PJ, Burch JM: Blunt carotid and vertebral arterial injuries. *World J Surg*. 2001, 25:1036-43. [10.1007/s00268-001-0056-x](https://doi.org/10.1007/s00268-001-0056-x)
- Miller PR, Fabian TC, Bee TK, Timmons S, Chamsuddin A, Finkle R, Croce MA: Blunt cerebrovascular injuries: diagnosis and treatment. *J Trauma*. 2001, 51:279-85. [10.1097/00005373-200108000-00009](https://doi.org/10.1097/00005373-200108000-00009)
- Fleck SK, Langner S, Baldauf J, Kirsch M, Kohlmann T, Schroeder HW: Incidence of blunt craniocervical artery injuries: use of whole-body computed tomography trauma imaging with adapted computed tomography angiography. *Neurosurgery*. 2011, 69:615-23. [10.1227/NEU.0b013e31821a8701](https://doi.org/10.1227/NEU.0b013e31821a8701)
- Fusco MR, Harrigan MR: Cerebrovascular dissections: a review. Part II: blunt cerebrovascular injury. *Neurosurgery*. 2011, 68:517-30. [10.1227/NEU.0b013e3181fe2fda](https://doi.org/10.1227/NEU.0b013e3181fe2fda)

7. Miller PR, Fabian TC, Croce MA, et al.: Prospective screening for blunt cerebrovascular injuries: analysis of diagnostic modalities and outcomes. *Ann Surg.* 2002, 236:386-93. [10.1097/01.SLA.0000027174.01008.A0](#)
8. Munding GS, Dorafshar AH, Gilson MM, Mithani SK, Manson PN, Rodriguez ED: Blunt-mechanism facial fracture patterns associated with internal carotid artery injuries: recommendations for additional screening criteria based on analysis of 4,398 patients. *J Oral Maxillofac Surg.* 2013, 71:2092-100. [10.1016/j.joms.2013.07.005](#)
9. Berne JD, Cook A, Rowe SA, Norwood SH: A multivariate logistic regression analysis of risk factors for blunt cerebrovascular injury. *J Vasc Surg.* 2010, 51:57-64. [10.1016/j.jvs.2009.08.071](#)
10. Kerwin AJ, Bynoe RP, Murray J, et al.: Liberalized screening for blunt carotid and vertebral artery injuries is justified. *J Trauma.* 2001, 51:308-14. [10.1097/00005373-200108000-00013](#)
11. Hoit DA, Schirmer CM, Weller SJ, Lisbon A, Edlow JA, Malek AM: Angiographic detection of carotid and vertebral arterial injury in the high-energy blunt trauma patient. *J Spinal Disord Tech.* 2008, 21:259-66. [10.1097/BSD.0b013e318141fce8](#)
12. Utter GH, Hollingworth W, Hallam DK, Jarvik JG, Jurkovich GJ: Sixteen-slice CT angiography in patients with suspected blunt carotid and vertebral artery injuries. *J Am Coll Surg.* 2006, 203:838-48. [10.1016/j.jamcollsurg.2006.08.003](#)
13. van Beek GJ, Merckx CA: Changes in the pattern of fractures of the maxillofacial skeleton. *Int J Oral Maxillofac Surg.* 1999, 28:424-8. [10.1034/j.1399-0020.1999.280605.x](#)
14. Gassner R, Tuli T, Hächl O, Rudisch A, Ulmer H: Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries. *J Craniomaxillofac Surg.* 2003, 31:51-61. [10.1016/s1010-5182\(02\)00168-5](#)
15. Jin KS, Lee H, Sohn JB, Han YS, Jung DU, Sim HY, Kim HS: Fracture patterns and causes in the craniofacial region: an 8-year review of 2076 patients. *Maxillofac Plast Reconstr Surg.* 2018, 40:29. [10.1186/s40902-018-0168-y](#)
16. Haug RH, Prather J, Indresano AT: An epidemiologic survey of facial fractures and concomitant injuries. *J Oral Maxillofac Surg.* 1990, 48:926-32. [10.1016/0278-2391\(90\)90004-1](#)
17. Khallaf M, Shahine MS: Epidemiological features of patients with craniomaxillofacial fractures: a single centre study. *Open J Mod Neurosurg.* 2019, 9:132-44. [10.4236/ojmn.2019.92013](#)
18. Kelts G, Maturo S, Couch ME, Schmalbach CE: Blunt cerebrovascular injury following craniomaxillofacial fractures: a systematic review. *Laryngoscope.* 2017, 127:79-86. [10.1002/lary.26186](#)
19. Varjonen EA, Bensch FV, Pyhälä TT, Koivikko MP, Snäll J: Remember the vessels! Craniofacial fracture predicts risk for blunt cerebrovascular injury. *J Oral Maxillofac Surg.* 2018, 76:1509. [10.1016/j.joms.2018.03.035](#)
20. Montovani JC, de Campos LM, Gomes MA, de Moraes VR, Ferreira FD, Nogueira EA: Etiology and incidence facial fractures in children and adults. *Braz J Otorhinolaryngol.* 2006, 72:235-41. [10.1016/s1808-8694\(15\)30061-6](#)
21. Bakardjiev A, Pechalova P: Maxillofacial fractures in Southern Bulgaria - a retrospective study of 1706 cases. *J Craniomaxillofac Surg.* 2007, 35:147-50. [10.1016/j.jcms.2007.01.005](#)
22. Hogg NJ, Stewart TC, Armstrong JE, Girotti MJ: Epidemiology of maxillofacial injuries at trauma hospitals in Ontario, Canada, between 1992 and 1997. *J Trauma.* 2000, 49:425-32. [10.1097/00005373-200009000-00007](#)
23. Al Ahmed HE, Jaber MA, Abu Fanas SH, Karas M: The pattern of maxillofacial fractures in Sharjah, United Arab Emirates: a review of 230 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2004, 98:166-70. [10.1016/j.tripleo.2004.01.020](#)
24. Naidu B, Vivek V, Visvanathan K, Shekhar R, Ram S, Ganesh K: A study of clinical presentation and management of base of skull fractures in our tertiary care centre. *Interdiscip Neurosurg.* 2021, 23:100906. [10.1016/j.inat.2020.100906](#)
25. Weber CD, Lefering R, Kobbe P, et al.: Blunt cerebrovascular artery injury and stroke in severely injured patients: an international multicenter analysis. *World J Surg.* 2018, 42:2043-53. [10.1007/s00268-017-4408-6](#)
26. Hundesmarck D, Slooff WM, Homans JF, et al.: Blunt cerebrovascular injury: incidence and long-term follow-up. *Eur J Trauma Emerg Surg.* 2021, 47:161-70. [10.1007/s00068-019-01171-9](#)
27. Savoie KB, Shi J, Wheeler K, Xiang H, Kenney BD: Pediatric blunt cerebrovascular injuries: a national trauma database study. *J Pediatr Surg.* 2020, 55:917-20. [10.1016/j.jpedsurg.2020.01.043](#)
28. Jones TS, Burlew CC, Kornblith LZ, et al.: Blunt cerebrovascular injuries in the child. *Am J Surg.* 2012, 204:7-10. [10.1016/j.amjsurg.2011.07.015](#)
29. Malhotra AK, Camacho M, Ivatury RR, et al.: Computed tomographic angiography for the diagnosis of blunt carotid/vertebral artery injury: a note of caution. *Ann Surg.* 2007, 246:632-42. [10.1097/SLA.0b013e3181568cab](#)