

Western Trauma Association Critical Decisions in Trauma: Penetrating neck trauma

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This is a recommended algorithm of the Western Trauma Association for the management of penetrating neck trauma that has penetrated the platysma muscle of the neck. Because of the paucity of recent prospective randomized trials on the evaluation and management of penetrating neck injury, the current algorithm and recommendations are based on available published prospective cohort, observational, and retrospective studies and the expert opinion of the Western Trauma Association members. The algorithm (Fig. 1.) and accompanying text represents a safe and reasonable approach to this difficult injury type and attempts to incorporate the advent of recent advances in radiographic screening and selective or expectant management practice. We recognize that there will be variability in decision making, local resources, institutional consensus, and patient-specific factors that may require deviation from the algorithm presented. This annotated algorithm is meant to serve as a basis from which protocols at individual institutions can be developed or serve as a quick bedside reference for clinicians. The algorithm contains letters A through J, which correspond to the lettered text. Their

purpose is to succinctly navigate the reader thru the algorithm and discuss those points, which require further elucidation or where data are lacking.¹⁻³

HISTORICAL PERSPECTIVE

Penetrating wounds to the neck are common in civilian trauma centers, with appreciably high morbidity and mortality depending on the mechanism of injury (gunshot wounds vs. stab wounds), the type of injury (vascular, aerodigestive), and the timeliness in diagnosis and management of significant neck injury.⁴⁻⁶ The management of penetrating neck injury is dependent on the anatomic level of the injury.⁵ The specific anatomic borders, which define the zones of penetrating neck injury, have varied using either the cricoid cartilage or level of clavicles to differentiate Zone I from Zone II injury, which is thought to represent a minor modification of no real clinical significance (Table 1).⁷⁻⁹ For the current algorithm, the original zones using the clavicles to demarcate Zone I from Zone II will be used, with the posterior border of the sternocleidomastoid demarcating the anterior and posterior neck. During the past two decades, the evaluation and management of penetrating neck injuries have significantly evolved, moving from mandatory neck exploration of Zone II injuries and the attributable high negative exploration rate toward expectant and selective operative management with greater use of computed tomographic imaging-based assessment.¹⁰⁻¹⁵

ANNOTATED TEXT FOR THE ALGORITHM

A. Initial management of patients with penetrating neck injury, which violates the platysma, should follow the advanced trauma life support guidelines, which provide the framework to identify those patients with life-threatening injuries and appropriately prioritize treatment.¹⁶ Patients who during their primary survey demonstrate “hard signs” (Table 2.) or hemodynamic instability^{5,17} require expeditious transfer to the operating room delayed only by securing an unstable airway, with a surgical airway if attempts at oral-tracheal intubation are unsuccessful,¹⁸⁻²⁰ and attempting tamponade of active bleeding while en route. If direct pressure is unable to minimize significant active bleeding, focused attempts with balloon catheter tamponade may be of benefit.^{21,22}

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The Western Trauma Association (WTA) develops algorithms to provide guidance and recommendations for particular practice areas but does not establish the standard of care. The WTA algorithms are based on the evidence available in the literature and the expert opinion of the task force in the recent time frame of the publication. The WTA considers use of the algorithm to be voluntary. The ultimate determination regarding its application is to be made by the treating physician and health care professionals with full consideration of the individual patient’s clinical status as well as available institutional resources; it is not intended to take the place of health care providers’ judgment in diagnosing and treating particular patients.

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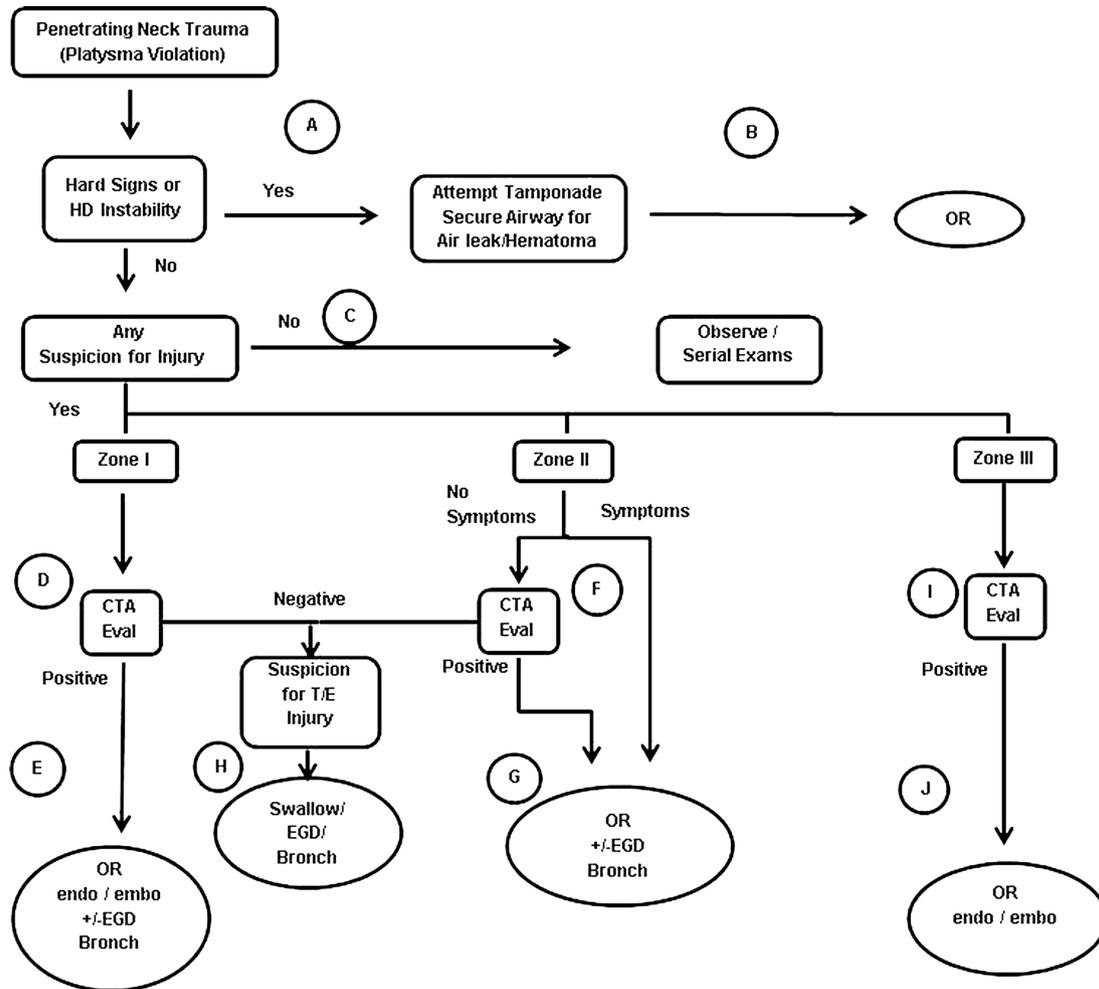


Figure 1. Western Trauma Association management algorithm for penetrating neck trauma.

B. Operative exposure for penetrating neck injuries with “hard signs” or hemodynamic instability are determined by the anatomic zone of injury.⁸ Most penetrating neck injuries can be approached via an anterior sternocleidomastoid incision. Zone I neck injuries may require a median sternotomy with extension to an anterior sternocleidomastoid incision or supraclavicular incision with or without clavicular head resection. For Zone II transcervical injuries, a transverse cervical collar incision may provide access to both sides of the neck, with the potential to extend along the anterior sternocleidomastoid muscle. Zone III represents a difficult

anatomic zone of injury for distal vascular control. At times, subluxation, dislocation, or resection of the mandible may be necessary to gain operative vascular control. Endovascular techniques have become a useful adjunct and an addition to the armamentarium available for the management of the acutely injured patient.^{23–26} Depending on institutional availability, Zone I or III vascular injuries may benefit from endovascular management to provide either vascular control or definitive care, if hemodynamic stability can be obtained, if bleeding can be stabilized, or if these techniques can be performed in an expeditious fashion in the

TABLE 1. Anatomic Zones of Injury for Penetrating Neck Trauma^{7,8}

Zone	Original	Modification
I	Below level of clavicles	Clavicles/sternum to cricoid cartilage
II	Between clavicles and the angle of the mandible	Cricoid cartilage to the angle of mandible
III	Superior to the angle of mandible to the skull base	Superior to the angle of mandible to the skull base

TABLE 2. Overt or “Hard Signs” Suggestive of Major Vascular or Aerodigestive Tract Injury

Airway compromise
Massive subcutaneous emphysema/air bubbling through wound
Expanding or pulsatile hematoma
Active bleeding
Shock
Neurologic deficit
Hematemesis

operating room.^{26–29} Vertebral artery injuries can be challenging, and for these difficult-to-access injuries, external bone wax compression can provide temporary control of bleeding, potentially allowing time for definitive surgical control of bleeding or allowing time for endovascular techniques to obtain definitive control of bleeding, if required. Alternatively, proximal ligation at the vessels origin or insertion of a Fogarty catheter into the proximal vertebral artery for occlusive control may be performed.^{23,30–32}

When a common or internal carotid arterial injury is identified by neck exploration, current consensus agrees that primary repair of the artery is preferred to ligation, irrespective of any abnormality in focal preoperative neurologic examination findings.^{33,34} A majority of jugular venous injuries are probably unrecognized without exploration owing to the low-pressure venous system.³⁵ The majority of jugular venous injuries can be managed safely nonoperatively.³⁶ In those that result in significant hemorrhage or are found at exploration, ligation can be performed with little risk of ramifications.³⁵

C. Patients without indications for mandatory neck exploration who remain hemodynamically stable can be managed expectantly with observation/serial examinations or undergo further radiographic evaluation, depending on the level of suspicion for injury, the symptoms demonstrated by the patient, and the anatomic zone of injury. Patients without symptoms such as dysphagia, voice change, hemoptysis, hematemesis, x-ray finding abnormality, or a bruit/thrill can be safely managed expectantly with serial examinations and observation.^{5,17} A thorough physical examination following penetrating neck injury has been demonstrated to be highly sensitive (>95%) for detecting arterial vascular injury but a lower sensitivity for aerodigestive tract injuries.^{15,37,38} Patients who are asymptomatic with Zone I injuries require a high index of suspicion because physical examination findings can be anatomically obscured.^{5,39} In the most recent prospective, multicenter study, evaluating 453 patients over 31 months, all 189 patients without physical examination findings of vascular or aerodigestive tract injury were observed and discharged without a missed injury (mean, 2.6-day follow-up).¹⁵ However, owing to the greater morbidity and mortality associated with delayed management of esophageal injury and potential lower sensitivity of physical examination, the most current published clinical practice guidelines recommend that physical examination alone is inadequate to rule out injuries to the aerodigestive tract.⁴ Similarly, physical examination was shown to have a lower sensitivity of detecting venous injuries as compared with computed tomographic angiography (CTA); however, most venous injuries do not require intervention.³⁷ Stable patients with transcervical gunshot wounds may warrant further radiographic evaluation owing to their greater injury potential and likelihood to involve more than one anatomic zone of injury.⁴⁰

D. Zone I patients without indications for neck exploration should undergo CTA of the chest and neck to evaluate for

both vascular and aerodigestive injuries. Initially, CTA was primarily considered for its ability to detect vascular injury, but more recent series have demonstrated a high sensitivity for detecting aerodigestive tract injuries.^{15,17} No specific literature focuses on the management of Zone I penetrating injuries, but owing to the more difficult surgical exposure options and growing endovascular techniques available that may benefit the stable patient with vascular injury, a road map provided by CTA, which characterizes the location and extent of a vascular injury and demonstrates the trajectory or tract of the wound for potential aerodigestive injury, is invaluable for the management planning.²³

E. In hemodynamically stable patients with CTA evidence of Zone I injury, further intervention is typically required. Successful endovascular approaches for arterial injuries using covered stents for Zone I injuries have been documented, although primarily as case reports and small series.^{26,41} When endovascular techniques are not indicated, are unavailable, or are unsuccessful, standard open surgical techniques using proximal and distal vascular control is required for arterial/venous injuries.

Hemodynamically stable patients with documented Zone I aerodigestive injury by CTA should undergo prompt operative intervention in most cases because this is associated with better outcome.⁴² The treatment strategy for esophageal injury is typically determined by the clinical status of the patient, associated injuries, and extent and location of esophageal injury. Access can be from the neck or the chest, or at times, both are required. Goals for early operative management include debridement of the esophagus, primary closure with buttressing if possible, and adequate drainage.^{42–44} Tracheal injury can usually be primarily repaired using absorbable suture after appropriate debridement. Interposition of a well-vascularized tissue between a combination of tracheal and esophageal injuries is essential to reduce the risk of fistula development.⁴⁵

Patients without documented aerodigestive injury by CTA imaging but with concerning trajectory should undergo further evaluation with esophagoscopy or esophagography and bronchoscopy, possibly intraoperatively if other injuries are being treated operatively.

F. Those patients with symptomatic Zone II injuries should undergo early operative neck exploration by either the standard anterior sternocleidomastoid incision or cervical collar incision, depending on the nature of the injury. If during operative exploration an adequate evaluation of the trachea or esophagus cannot be performed or the trajectory of the wounds elicits concern for aerodigestive injury, on-table bronchoscopy and esophagoscopy can be performed and are adequate to rule out significant aerodigestive injury.⁴ Hemodynamically stable patients with Zone II injury without symptoms or suspicion can be safely managed expectantly with observation/serial examinations. Zone II patients with suspicion for injury but without symptoms on physical examination should undergo CTA of the neck to evaluate for both vascular and aerodigestive injuries.

- G. In hemodynamically stable patients with CTA evidence of Zone II injury, operative intervention is typically required because access is simple and repairs are definitive. Despite much enthusiasm for endovascular techniques, the majority of Zone II vascular injuries should be managed via standard open operative techniques. The role of endovascular stenting for traumatic vascular injury will likely increase over time as our experience grows;^{27–29} however, long-term outcome data regarding these stents being placed in the typically young trauma patient remain unavailable at this time.²³ The requirement for long-term antiplatelet therapy or anticoagulation remains similarly obscure.⁴⁶
- H. In those patients with Zone I and II injuries who undergo CTA evaluation without direct evidence of aerodigestive tract injury but secondary to wound trajectory, proximity to other injuries, or any evolving symptoms, should undergo additional evaluation. Some controversy regarding the sensitivity of esophagography, rigid esophagoscopy, flexible esophagoscopy, or a combination of these studies exists in the literature.^{47–50} Current practice guidelines recommend that esophagography or esophagoscopy can be used to rule out esophageal injury and add that an expeditious evaluation should occur owing to the increased morbidity associated with delayed esophageal repair.^{4,42}
- I. Hemodynamically stable Zone III patients with suspicion for injury should undergo CTA of the neck and head to evaluate for vascular and aerodigestive injuries.⁵¹
- J. In those stable patients with radiographic evidence of Zone III arterial injury, further diagnostic or therapeutic intervention is often required. Inaccessible arterial injuries may be addressed with embolization when a vessel can be sacrificed or with covered stenting when patency is required.²³ Penetrating vertebral artery injuries are relatively rare but can be challenging.³⁰ One of the largest series for vertebral artery penetrating trauma demonstrated that approximately 20% of patients required emergency surgery for instability necessitating vertebral artery ligation or the use of bone wax compression, while more than 33% required embolization.³¹ More recent series demonstrate that the majority of penetrating vertebral arterial injuries can be successfully managed via an endovascular approach.³² Zone III aerodigestive or pharyngeal injuries also require early diagnosis and management.⁵² Pharyngeal penetrating injury carries similar risks of delayed sepsis, descending retropharyngitis, and resultant mediastinitis as esophageal injury does. It has been demonstrated that contrast swallow studies are less sensitive in detecting hypopharyngeal injuries as compared with esophageal injury and flexible nasoendoscopy or video endoscopy should be part of the “trauma surgeon’s armamentarium.”^{51,53}

REFERENCES

1. McIntyre RC Jr, Moore FA, Davis JW, Cocanour CS, West MA, Moore EE Jr. Western Trauma Association critical decisions in trauma: foreword. *J Trauma*. 2008;65(5):1005–1006.
2. Burlew CC, Moore EE, Moore FA, et al. Western Trauma Association critical decisions in trauma: resuscitative thoracotomy. *J Trauma Acute Care Surg*. 2012;73(6):1357–1361.
3. Kozar RA, Moore FA, Moore EE, et al. Western Trauma Association critical decisions in trauma: nonoperative management of adult blunt hepatic trauma. *J Trauma*. 2009;67(6):1144–1148; discussion 1148–1149.
4. Tisherman SA, Bokhari F, Collier B, et al. Clinical practice guideline: penetrating zone II neck trauma. *J Trauma*. 2008;64(5):1392–1405.
5. Biffi WL, Moore EE, Rehse DH, Offner PJ, Franciose RJ, Burch JM. Selective management of penetrating neck trauma based on cervical level of injury. *Am J Surg*. 1997;174(6):678–682.
6. Burgess CA, Dale OT, Almeyda R, Corbridge RJ. An evidence based review of the assessment and management of penetrating neck trauma. *Clin Otolaryngol*. 2012;37(1):44–52.
7. Monson DO, Saletta JD, Freeark RJ. Carotid vertebral trauma. *J Trauma*. 1969;9(12):987–999.
8. Roon AJ, Christensen N. Evaluation and treatment of penetrating cervical injuries. *J Trauma*. 1979;19(6):391–397.
9. Mattox KL, Moore EE, Feliciano DV, eds. *Trauma*. 7th ed. New York: McGraw Hill; 2013.
10. Fogelman MJ, Stewart RD. Penetrating wounds of the neck. *Am J Surg*. 1956;91(4):581–593; discussion 593–586.
11. Sheely CH 2nd, Mattox KL, Beall AC Jr, DeBakey ME. Penetrating wounds of the cervical esophagus. *Am J Surg*. 1975;130(6):707–711.
12. Sheely CH 2nd, Mattox KL, Reul GJ Jr, Beall AC Jr, DeBakey ME. Current concepts in the management of penetrating neck trauma. *J Trauma*. 1975;15(10):895–900.
13. Jurkovich GJ, Zingarelli W, Wallace J, Curreri PW. Penetrating neck trauma: diagnostic studies in the asymptomatic patient. *J Trauma*. 1985; 25(9):819–822.
14. Golueke PJ, Goldstein AS, Sclafani SJ, Mitchell WG, Shaftan GW. Routine versus selective exploration of penetrating neck injuries: a randomized prospective study. *J Trauma*. 1984;24(12):1010–1014.
15. Inaba K, Branco BC, Menaker J, et al. Evaluation of multidetector computed tomography for penetrating neck injury: a prospective multicenter study. *J Trauma Acute Care Surg* 2012;72:576–583; discussion 583–574; quiz 803–804.
16. American College of Surgeons Committee on Trauma. *Advanced Trauma Life Support for Doctors*. 8th ed. Chicago, IL: American College of Surgeons; 2012.
17. Demetriades D, Theodorou D, Cornwell E, et al. Evaluation of penetrating injuries of the neck: prospective study of 223 patients. *World J Surg*. 1997;21(1):41–47; discussion 47–48.
18. Mandavia DP, Qualls S, Rokos I. Emergency airway management in penetrating neck injury. *Ann Emerg Med*. 2000;35(3):221–225.
19. Tallon JM, Ahmed JM, Sealy B. Airway management in penetrating neck trauma at a Canadian tertiary trauma centre. *CJEM*. 2007;9(2):101–104.
20. Vassiliu P, Baker J, Henderson S, Alo K, Velmahos G, Demetriades D. Aerodigestive injuries of the neck. *Am Surg*. 2001;67(1):75–79.
21. Gilroy D, Lakhoo M, Charalambides D, Demetriades D. Control of life-threatening haemorrhage from the neck: a new indication for balloon tamponade. *Injury*. 1992;23(8):557–559.
22. Navsaria P, Thoma M, Nicol A. Foley catheter balloon tamponade for life-threatening hemorrhage in penetrating neck trauma. *World J Surg*. 2006; 30(7):1265–1268.
23. O’Brien PJ, Cox MW. A modern approach to cervical vascular trauma. *Perspect Vasc Surg Endovasc Ther*. 2011;23(2):90–97.
24. Cox MW, Whittaker DR, Martinez C, Fox CJ, Feuerstein IM, Gillespie DL. Traumatic pseudoaneurysms of the head and neck: early endovascular intervention. *J Vasc Surg*. 2007;46(6):1227–1233.
25. Reuben BC, Whitten MG, Sarfati M, Kraiss LW. Increasing use of endovascular therapy in acute arterial injuries: analysis of the National Trauma Data Bank. *J Vasc Surg*. 2007;46(6):1222–1226.

DISCLOSURE

The authors declare no conflicts of interest.

26. Gilani R, Tsai PI, Wall MJ Jr., Mattox KL. Overcoming challenges of endovascular treatment of complex subclavian and axillary artery injuries in hypotensive patients. *J Trauma Acute Care Surg.* 2012;73(3):771–773.
27. Duane TM, Parker F, Stokes GK, Parent FN, Britt LD. Endovascular carotid stenting after trauma. *J Trauma.* 2002;52(1):149–153.
28. McNeil JD, Chiou AC, Gunlock MG, Grayson DE, Soares G, Hagino RT. Successful endovascular therapy of a penetrating zone III internal carotid injury. *J Vasc Surg.* 2002;36(1):187–190.
29. 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):1561–1566.
30. Meier DE, Brink BE, Fry WJ. Vertebral artery trauma: acute recognition and treatment. *Arch Surg.* 1981;116(2):236–239.
31. Mwiipatayi BP, Jeffery P, Beningfield SJ, Motale P, Tunnicliffe J, Navsaria PH. Management of extra-cranial vertebral artery injuries. *Eur J Vasc Endovasc Surg.* 2004;27(2):157–162.
32. Herrera DA, Vargas SA, Dublin AB. Endovascular treatment of traumatic injuries of the vertebral artery. *AJNR Am J Neuroradiol.* 2008;29(8):1585–1589.
33. Feliciano DV. Management of penetrating injuries to carotid artery. *World J Surg.* 2001;25(8):1028–1035.
34. Liekweg WG Jr, Greenfield LJ. Management of penetrating carotid arterial injury. *Ann Surg.* 1978;188(5):587–592.
35. Kumar SR, Weaver FA, Yellin AE. Cervical vascular injuries: carotid and jugular venous injuries. *Surg Clin North Am.* 2001;81(6):1331–1344, xii–xiii.
36. Inaba K, Munera F, McKenney MG, et al. The nonoperative management of penetrating internal jugular vein injury. *J Vasc Surg.* 2006;43(1):77–80.
37. Gonzalez RP, Falimirski M, Holevar MR, Turk B. Penetrating zone II neck injury: does dynamic computed tomographic scan contribute to the diagnostic sensitivity of physical examination for surgically significant injury? A prospective blinded study. *J Trauma.* 2003;54(1):61–64; discussion 64–65.
38. Inaba K, Munera F, McKenney M, et al. Prospective evaluation of screening multislice helical computed tomographic angiography in the initial evaluation of penetrating neck injuries. *J Trauma.* 2006;61(1):144–149.
39. Demetriades D, Charalambides D, Lakhoo M. Physical examination and selective conservative management in patients with penetrating injuries of the neck. *Br J Surg.* 1993;80(12):1534–1536.
40. Hirshberg A, Wall MJ, Johnston RH Jr, Burch JM, Mattox KL. Transcervical gunshot injuries. *Am J Surg.* 1994;167(3):309–312.
41. DuBose JJ, Rajani R, Gilani R, et al. Endovascular management of axillo-subclavian arterial injury: a review of published experience. *Injury.* 2012; 43(11):1785–1792.
42. Asensio JA, Chahwan S, Forno W, et al. Penetrating esophageal injuries: multicenter study of the American Association for the Surgery of Trauma. *J Trauma.* 2001;50(2):289–296.
43. Bryant AS, Cerfolio RJ. Esophageal trauma. *Thorac Surg Clin.* 2007; 17(1):63–72.
44. Winter RP, Weigelt JA. Cervical esophageal trauma. Incidence and cause of esophageal fistulas. *Arch Surg.* 1990;125(7):849–851; discussion 851–842.
45. Mathisen DJ, Grillo H. Laryngotracheal trauma. *Ann Thorac Surg.* 1987;43(3):254–262.
46. Bhatt DL, Kapadia SR, Bajzer CT, et al. Dual antiplatelet therapy with clopidogrel and aspirin after carotid artery stenting. *J Invasive Cardiol.* 2001;13(12):767–771.
47. Weigelt JA, Thal ER, Snyder WH 3rd, Fry RE, Meier DE, Kilman WJ. Diagnosis of penetrating cervical esophageal injuries. *Am J Surg.* 1987; 154(6):619–622.
48. Wood J, Fabian TC, Mangiante EC. Penetrating neck injuries: recommendations for selective management. *J Trauma.* 1989;29(5):602–605.
49. Ngakane H, Muckart DJ, Luvuno FM. Penetrating visceral injuries of the neck: results of a conservative management policy. *Br J Surg.* 1990; 77(8):908–910.
50. Srinivasan R, Haywood T, Horwitz B, Buckman RF, Fisher RS, Krevsky B. Role of flexible endoscopy in the evaluation of possible esophageal trauma after penetrating injuries. *Am J Gastroenterol.* 2000; 95(7):1725–1729.
51. Offiah C, Hall E. Imaging assessment of penetrating injury of the neck and face. *Insights Imaging.* 2012;3(5):419–431.
52. Bagheri SC, Khan HA, Bell RB. Penetrating neck injuries. *Oral Maxillofac Surg Clin North Am.* 2008;20(3):393–414.
53. Ahmed N, Massier C, Tassie J, Whalen J, Chung R. Diagnosis of penetrating injuries of the pharynx and esophagus in the severely injured patient. *J Trauma.* 2009;67(1):152–154.