The Trauma Professional's Blog

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What Is BCVI?

There seems to be some confusion as to what the acronym BCVI stands for. Some people believe that it stands for **b**lunt **c**erebro**v**ascular **i**njury. This is not correct, because that term refers to injury of just about any vessel inside the skull.

The correct interpretation is **b**lunt **c**arotid and **v**ertebral artery **i**njury. This term refers to any portion of those two pairs of vessels, from where they arise on the great vessels all the way up into the base of the skull.

These arteries are relatively protected from harm during blunt trauma. But given enough energy, bad things can happen. Fortunately, injuries to these structures are not very common, but unfortnately many trauma professionals under-appreciate their frequency and severity.

This month, I am going to provide an update on what we know about BCVI. I will try to tease out the true incidence, review the (several) screening systems, and discuss the various ways to manage this issue.

How Common Is BCVI, Really?

Blunt carotid and vertebral artery injuries (BCVI) are an under-appreciated problem after blunt trauma. Several screening tools have been published over the years, but they tend to be unevenly applied at individual trauma centers. I will discuss them in detail in the next section.

Inside This Issue

Trauma Conferences

The vast majority of trauma meetings, symposia, and conferences have been cancelled. I am excited to say that a few are moving forward with their plans, providing valuable conferences in an electronic format. These include large meetings held by the major trauma organizations.

Eastern Association for the Surgery of Trauma
Date: January 13-14, 2021
Where: Virtual
Registration: www.east.org

For the longest time, the overall incidence of BCVI was thought to be low, on the order of 1-2%. This is the number I learned years ago, and it has not really changed over time.

But how do we know for sure? Well, the group at Birmingham retrospectively reviewed **every CT angiogram (CTA) of the neck they did in a recent two-year period.** They did this after adopting a policy of imaging each and every one of their major blunt trauma patients for BCVI. Each patient chart was also evaluated to see if the patient met any of the criteria for the three commonly used screening systems.

During the study period, a total of 5,634 of 6,800 blunt trauma patients underwent BCVI screening with CTA of the neck. They discovered that 471 patients (8.4%) were positive for BCVI!

This is a shocking 8x higher than we expected! Why hasn't this been obvious until now? Most likely because we were previously only aware of patients who became symptomatic. Luckily, many of these patients never exhibit any symptoms at all.

So why should we be worried? This is one of those clinical entities like blunt thoracic aortic disruption that potentially has terrible consequences if ignored. Although the number of patients who develop sequelae from their BCVI is small, suffering a stroke can be catastrophic.

Should we perform a screening study for all blunt trauma patients? Seems like overkill, or is it? Is there any way we be more selective about it? Read on!

Screening For BCVI

Identifying just the right patients requires a good screening system. And what makes a good one? High sensitivity and high specificity. Unfortunately, it is difficult to find any screening system that fits the bill.

Currently, there are three systems in use: Denver, Expanded Denver, and Modified Memphis. Let's look at each in detail.

Denver BCVI Screening

There is an original Denver screening system, and a more recent modification. The original system was divided into mechanism, physical signs, and radiographic findings. It was rather rudimentary and evolved into the following which uses both signs and symptoms, and high-risk factors.

Signs and symptoms

- potential arterial hemorrhage from the neck, nose, or mouth
- cervical bruit in patients <50 years of age
- expanding cervical hematoma
- focal neurologic deficit (transient ischemic attack, hemiparesis, vertebrobasilar symptoms, Horner syndrome) incongruous with head CT findings
- stroke on CT

Risk factors

- Le Fort II or III mid-face fractures
- Cervical spine fractures (including subluxations), especially fractures involving transverse foramen or C1-C3 Vertebrae
- Basilar skull fracture and involvement of carotid canal
- Diffuse axonal injury with GCS <8
- Near hanging with anoxic brain injury
- Seat belt sign (or other soft tissue neck injury) especially if significant associated swelling or altered level of consciousness

The Denver group reviewed their criteria in 2012 and found that 20% of the patients who had identified BCVI did not meet any of their criteria. And obviously, this number cannot include those who were never symptomatic and therefore never discovered.

Based on their analysis, they added several additional risk factors to the original system:

- Mandible fracture
- Complex skull fracture/basilar skull fracture/occipital condyle fracture
- TBI with thoracic injuries
- Scalp degloving
- Thoracic vascular injuries
- Blunt cardiac rupture

The downside of these modifications is that they are a little more complicated to identify. The original criteria were fairly straightforward yes/no items. But "TBI with thoracic injuries?" Both the TBI part and the thoracic injury part are very vague. This modification casts a wider net for BCVI, but the holes in the net are much larger.

Memphis BCVI Screening

Let's move on to the modified Memphis system for identifying BCVI. It consists of seven findings that overlap significantly with the Denver criteria. The underlined phrases indicated the modifications that were applied to the original criteria.

- base of skull fracture with involvement of the carotid canal
- <u>base of skull fracture with involvement of petrous temporal bone</u>
- cervical spine fracture <u>(including subluxation, transverse foramen involvement, and upper cervical spine fracture)</u>
- neurological exam findings not explained by neuroimaging
- Horner syndrome
- Le Fort II or III fracture pattern
- neck soft tissue injury (e.g. seatbelt sign, hanging, hematoma)

Interestingly, these modifications were first described in an abstract which was never published as a paper. Yet somehow, they stuck with us.

So there are now two or three possible systems to choose from when deciding to screen your blunt trauma patient. Which one is best?

Let's go back to the AAST abstract presented by the Birmingham group this year that I mentioned previously. Not only did they determine a more accurate incidence, but they also tested the three major screening systems to see how each fared. See Table 1.

Table 1. Screening diagnostic measures of three commonly used criteria for blunt cerebrovascular injury

Diagnostic	Denver	Expanded Denver	Modified Memphis
% Total patients screening positive	23.9%	41.4%	18.7%
False negative rate	42.2%	24.8%	52.4%
False positive rate	20.9%	38.3%	16.1%
Sensitivity	57.7%	75.2%	47.6%
Specificity	79.1%	61.7%	83.9%
Positive Predictive Value	20.2%	15.2%	21.2%
Negative Predictive Value	95.4%	96.5%	94.6%
Likelihood Ratio Positive	2.8	2.0	3.0

Look at these numbers closely. When any of these systems were applied and the screen was negative, the actual percentage of patients who still actually had the injury ranged from about 25% to 50%! Basically, it was a coin toss with the exception of the Expanded Denver criteria performing a little better.

If you are a patient and you actually have the injury, how often does any screening system pick it up? Oh, about one in five times. Again, this is not what we want to see.

So what to do? The Expanded Denver screen has a lower false negative rate, but the total number of positive screens, and hence the number of studies performed, doubles when it is used.

Here's how I think about it. BCVI is more common than we thought in major blunt trauma. If not identified, a catastrophic stroke may occur. Current screening systems successfully flag only 50% of patients for imaging. **So in my opinion, we need to image every patient who is already slated to receive a head and cervical spine CT after major blunt trauma!** At least until we have a more selective (and reliable) set of screening criteria.

References:

- ***(Denver)*** *Optimizing screening for blunt cerebrovascular injuries. Am J Surg. 1999;178:517–522.*
- ***(Expanded Denver)*** *Blunt cerebrovascular injuries: Redefining screening criteria in the era of* noninvasive diagnosis. J Trauma 2012;72(2):330-337.
- ***(Memphis)*** *Prospective screening for blunt cerebrovascular injuries: analysis of diagnostic modalities and outcomes. Ann Surg. 2002, 236 (3): 386-393.*
- ***(Modified Memphis)*** *Diagnosis of carotid and vertebral artery injury in major trauma with head injury. Crit care. 2010;14(supp1):S100.*

How To Grade BCVI

Only 10 years ago, it was a major production to identify BCVI. CT angiography was still in its early days, and scanner resolution and radiologist experience were major issues that impacted accuracy.

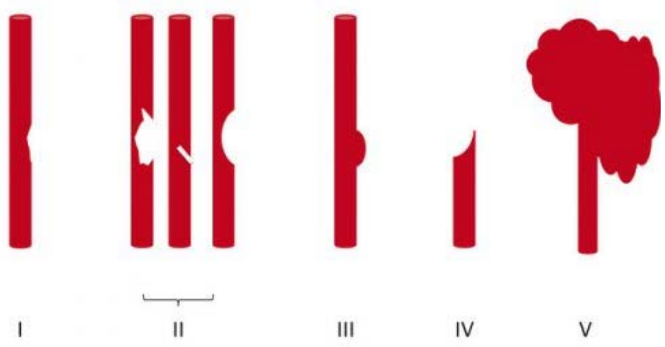
We've come a long way in a relatively short period of time, and current day scanners now have more than adequate resolution. It's also more common to have a radiologist with special skills reading these studies, the neuroradiologist. For these reasons, CT angiography has become the standard for diagnosis. It is also the most cost-effective. Only in very rare cases do we need to obtain a conventional contrast angiogram.

Once the study has been obtained, it's time to identify and classify the injury. The Denver group is also responsible for bringing us the grading system for BCVI. See the diagram below.

Here are the details:

Grade I: A mild intimal irregularity is seen. Note the abnormally narrowed area, representing a small intimal injury, possibly with a small amount of clot.

Grade II: This grade has several presentations. There may be an intraluminal thrombosis/hematoma with (left) or without (right) an intimal flap, or a flap alone (center)



Grade III: There is a full-thickness injury to the vessel with a contained extraluminal extravasation (pseudoaneurysm)

Grade IV: The vessel is completely occluded by flap or thrombus

Grade V: The artery is transected and freely extravasating

Remember, we always grade things for a reason! Ultimately, the injury grade will translate into the selection of treatment. We'll cover that in the next section.

Reference: Blunt carotid arterial injuries: implications of a new grading scale. J Trauma. 1999;47(5): 845-53.

Treatment Of BCVI

There are basically three modalities at our disposal for managing BCVI: **antithrombotic medication** (heparin and/or antiplatelet agents), **surgery**, and **endovascular procedures**. The choice of therapy is usually based on surgical accessibility and patient safety for anticoagulation. We do know that a number of studies have shown a decrease in stroke events in patients who are heparinized. Unfortunately, this is not always possible due to associated injuries. Antiplatelet agents are usually tolerated after acute trauma, especially low-dose aspirin. Several studies have shown little difference in outcomes in patients receiving heparin vs aspirin/clopidogrel for BCVI.

So what to do? Here are some broad guidelines:

- **Grade I (intimal flap).** Heparin or antiplatelet agents should be given. If heparin can be safely administered, it may be preferable in patients who will need other surgical procedures since it can be rapidly reversed just by stopping the infusion. These lesions generally heal completely on their own, so a followup CT angiogram should be scheduled in 1-2 weeks. Medication can be stopped when the lesion heals.
- **Grade II (flap/dissection/hematoma).** These injuries are more likely to progress, so heparin is preferred if it can be safely given. Stenting should be considered, especially if the lesion progresses. Long-term anti-platelet medication may be required.
- **Grade III (pseudoaneurysm).** Initial heparin therapy is preferred unless contraindicated. Stable pseudoaneurysms should be followed with CTA every 6 months. If the lesion enlarges, then surgical repair should be carried out in accessible injuries or stenting in inaccessible ones.
- **Grade IV (occlusion).** Heparin therapy should be initiated unless contraindicated. Patients who do not suffer a catastrophic stroke may do well with followup antithrombotic therapy. Endovascular treatment does not appear to be helpful.
- **Grade V (transection with extravasation).** This lesion is frequently fatal, and the bleeding must be addressed using the best available technique. For lesions that are surgically accessible, the patient should undergo the appropriate vascular procedure. Inaccessible injuries should undergo angiographic treatment and may require embolization to control bleeding without regard for the possibility of stroke.

References:

- *Scott WW, Sharp S, Figueroa SA, et al. Clinical and radiographic outcomes following traumatic Grade 1 and 2 carotid artery injuries: a 10-year retrospective analysis from a Level I trauma center. J Neurosurg 122:1196, 2015.*
- *Scott WW, Sharp S, Figueroa SA, et al. Clinical and radiographic outcomes following traumatic Grade 3 and 4 carotid artery injuries: a 10-year retrospective analysis from a Level 1 trauma center. J Neurosurg 122:610, 2015.*
- *Scott WW, Sharp S, Figueroa SA, et al. Clinical and radiological outcomes following traumatic Grade 1 and 2 vertebral artery injuries: a 10-year retrospective analysis from a Level 1 trauma center. J Neurosurg 121:450, 2015.*
- *Scott WW, Sharp S, Figueroa SA, et al. Clinical and radiological outcomes following traumatic Grade 3 and 4 vertebral artery injuries: a 10-year retrospective analysis from a Level I trauma center. The Parkland Carotid and Vertebral Artery Injury Survey. J Neurosurg 122:1202, 2015.*