Blunt cerebrovascular injury: The case for universal screening

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BACKGROUND: Current evidence-based screening algorithms for blunt cerebrovascular injury (BCVI) may miss more than 30% of carotid or vertebral artery injuries. We implemented universal screening for BCVI with computed tomography angiography of the neck at our level 1 trauma center, hypothesizing that only universal screening would identify all clinically relevant BCVIs.

METHODS: Adult blunt trauma activations from July 2017 to August 2019 underwent full-body computed tomography scan including computed tomography angiography neck with a 128-slice computed tomography scanner. We calculated sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of common screening criteria. We determined independent risk factors for BCVI using multivariate analyses.

RESULTS: A total of 4,659 patients fulfilled the inclusion criteria, 2.7% (n = 126) of which had 158 BCVIs. For the criteria outlined in the American College of Surgeons Trauma Quality Improvement Program Best Practices Guidelines, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 72.2%, 64.9%, 6.8%, 98.5%, and 65.2%, respectively; for the risk factors suggested in the more extensive expanded Denver criteria, they were 82.5%, 50.4%, 5.3%, 98.9%, and 51.4%, respectively. Twenty-three percent (n = 14) of patients with BCVI grade 3 or higher would not have been captured by any screening criteria. Cervical spine, facial, and skull base fractures were the strongest predictors of BCVI with odds ratios and 95% confidence intervals of 8.1 (5.4–12.1), 5.7 (2.2–15.1), and 2.7 (1.5–4.7), respectively. Eighty-three percent (n = 105) of patients with BCVI received antiplatelet agents or therapeutic anticoagulation, with 4% (n = 5) experiencing a bleeding complication, 3% (n = 4) a BCVI progression, and 8% (n = 10) a stroke.

CONCLUSION: Almost 20% of patients with BCVI, including a quarter of those with BCVI grade 3 or higher, would have gone undiagnosed by even the most extensive and sensitive BCVI screening criteria. Implementation of universal screening should strongly be considered to ensure the detection of all clinically relevant BCVIs. (*J Trauma Acute Care Surg.* 2020;89: 880–886. Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Diagnostic study, level III.

KEY WORDS: Blunt cerebrovascular injury; BCVI; incidence; sensitivity; universal screening.

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For more than three decades, screening criteria for blunt cerebrovascular injury (BCVI), that is, carotid or vertebral artery injury due to blunt trauma, have been developed and refined. Despite these efforts, more than 30% of patients with BCVI may not be reliably identified with established screening criteria.[1–5] While the reported incidence of BCVI is at a rather low 0.5% to 3.3%,[1,6–9] its potential complications if undiagnosed and untreated can be devastating with reported stroke and mortality rates of up to 25%.[6,10–13]

The trauma groups in Memphis and Denver established widely used screening criteria for BCVI about 20 years ago,[7,10,11,14] which have since then been refined and expanded.[2,4,5,15] The most recent version of the American College of Surgeons Trauma Quality Improvement Program (ACS TQIP) Best Practices Guidelines in Imaging[16] summarizes these criteria, describing 15 clinical findings or injury mechanisms that should prompt screening for BCVI with computed tomography angiography (CTA) of the neck, but cautioning that any patient with high-risk or high-energy mechanism should be considered for BCVI screening.

We implemented a universal screening protocol for BCVI with CTA of the neck for all major trauma activations at our level 1 trauma center in July 2017. Before this approach, our institution screened for BCVI following a list of 17 clinical risk factors (Table 1) based on the expanded Denver criteria.[4,5] Universal screening was implemented after we identified BCVI complications in patients not captured by these extensive screening criteria. We hypothesized that only universal screening would identify all clinically relevant BCVIs and allow for determination of their true incidence and risk factors in our patient population.

PATIENTS AND METHODS

At our level 1 trauma center, all major adult blunt trauma activations undergo whole-body, that is, head to abdomen/pelvis, computed tomography (CT) scan with a 128-slice scanner (Siemens SOMATOM Definition Flash, Siemens Healthineers AG, Erlangen, Germany), with a dedicated CTA neck including the

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TABLE 1. Institutional Screening Criteria (Based on the Expanded Denver Criteria)

Clinical findings concerning for BCVI
– Neck soft tissue injury ("seatbelt sign")
– Arterial bleeding or expanding cervical hematoma
– Cervical bruit
– Focal neurological deficit or neurologic findings unexplained by intracranial findings
– Ischemic stroke on CT scan
– Horner's syndrome
– Epistaxis
Mechanism with high risk for BCVI
– High-energy trauma
– (Near) hanging or choking
– Direct blow to the neck
– Cervical hyperextension or distraction
Injuries possibly associated with BCVI
– LeFort II or III facial fracture
– Mandibular fracture
– Cervical spine fracture (any level) except isolated spinous or transverse process fractures
– Basilar skull fracture
– Diffuse axonal injury or Glasgow Coma Scale ≤8
– Severe thoracic trauma with chest Abbreviated Injury Scale score 3 or higher

circle of Willis. Computed tomography imaging for patients with isolated extremity injury, for those younger than 15 years, and for pregnant patients occurs on a case-by-case basis. The whole-body CT and CTA neck protocols remained unchanged for the study period. The Institutional Review Board at Virginia Commonwealth University (VCU) reviewed and approved this study. All adult blunt trauma patients from July 2017 to August 2019, identified by review of the VCU trauma registry, were eligible for inclusion. Patients younger than 18 years, prisoners, pregnant patients, and those for whom CTA neck results were not available, were excluded. The electronic medical records of all patients with abnormal CTA neck and/or BCVI were reviewed.

Computed tomography angiography of the neck was considered positive for BCVI if the final attending radiologist report described cervical carotid or vertebral artery injury. In several cases, the initial CTA neck was equivocal for BCVI. If there was follow-up imaging within 48 hours that clearly demonstrated cervical carotid or vertebral artery injury, the patient was considered to have BCVI. If there was no further imaging or if follow-up imaging remained equivocal, we excluded the patient from the analysis because no clear statement on the presence of BCVI could be made. Grading for BCVI followed the Denver grading scale,[7] with grade 1 defined as intimal irregularity with less than 25% narrowing, grade 2 as dissection or intramural hematoma with more than 25% narrowing, grade 3 as pseudoaneurysm, grade 4 as occlusion, and grade 5 as transection with extravasation of contrast.

Per our institutional protocol, neurosurgery is consulted for all confirmed BCVIs on initial or follow-up imaging. Unless contraindicated because of concomitant injuries, a single antiplatelet agent is given for most grade 1 and 2 injuries, and dual antiplatelets or therapeutic anticoagulation for all grade 3 injuries. For grade 4 injuries, dual antiplatelets or therapeutic anticoagulation are used on case-by-case basis, often influenced by the presence of concomitant contralateral BCVI or other additional injuries.

Details on patient demographics, trauma mechanism, Injury Severity Score, BCVI grade, treatment, and complications were obtained from the trauma registry and electronic medical record, as applicable. We calculated sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of our institutional/expanded Denver criteria and of the less extensive list of criteria described in the ACS TQIP Best Practices Guidelines. Univariate and multivariate analyses were used to determine independent risk factors for BCVI. All risk factors associated with BCVI in the univariate model with two-tailed p values of 0.2 or less were entered into the multivariate model, in which two-tailed p values of 0.05 or less were considered statistically significant.

Statistical analyses were performed using JMP Pro 15.0 2019 (SAS Institute Inc., Cary, North Carolina). Categorical data were described as number (percentage) and compared using χ^2 and Fisher's exact test, as appropriate. Continuous data were expressed as median and interquartile range (25th to 75th percentile) for nonnormally distributed measurements and compared using the Wilcoxon-Mann-Whitney test. Results of the univariate and multivariate analyses were expressed as odds ratio (OR) with 95% confidence interval.

RESULTS

From July 2017 to August 2019, n = 4,687 trauma activations fulfilled the inclusion criteria. Computed tomography angiography of the neck for 28 patients (0.6%) remained equivocal (n = 23 equivocal for grade 1, n = 5 equivocal for grade 2 injury), which were excluded. A total of 4,659 patients were included in the final analysis. All details on patient demographics, trauma type, and outcomes are shown in Table 2. The incidence of BCVI was 2.7% (n = 126), with 48% (n = 61) of BCVI being grade 3 or higher. There was no grade 5 BCVI. Of the 126 patients with 158 BCVIs, 72% (n = 91) would have met the screening criteria outlined in the ACS TQIP Best Practices Guidelines in Imaging. Eighty-three percent (n = 104) would have met those of our institutional protocol and the expanded Denver criteria. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the expanded Denver criteria were 83%, 50%, 5%, 99%, and 51%, respectively (Figs. 1 and 2). The inclusion of severe thoracic trauma (chest Abbreviated Injury Scale score of 3 or higher) in the expanded Denver criteria identified 12 (10%) additional patients with BCVI, significantly increasing their sensitivity. However, 23% (n = 14) of patients with BCVI grade 3 or higher would not have been captured by any screening criteria (Table 3). These 14 patients had all been involved in MVCs, had a mean ± SD age of 41 ± 14 years, 57% (n = 8) were female, and none had been hemodynamically unstable upon arrival. The missed injuries involved carotid and vertebral artery in 50% (n = 7) each.

Of all 126 patients diagnosed with BCVI, 83% (n = 105) were treated with anticoagulation or antiplatelet agents. In the *treatment* group, 18%, 34%, 31%, and 16% of patients had

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TABLE 2. Demographic Characteristics, Injury Details, and Outcomes of Patients With and Without BCVI

	BCVI	No BCVI	*p*
Age, median (IQR), y	47 (34–61)	47 (29–63)	0.58
Female sex, n (%)	45 (35.7)	1,598 (35.3)	0.93
Top 3 trauma mechanisms, n (%)	—	—	0.14
Motor vehicle crash	73 (57.9)	2,062 (45.5)	—
Ground level fall	13 (10.3)	689 (15.2)	—
Blunt impact	16 (12.7)	961 (21.2)	—
High-energy mechanism, n (%)†	20 (15.9)	647 (14.3)	0.61
SBP ≤90 mm Hg, n (%)	11 (8.7)	89 (2.1)	<0.001*
Severe chest wall trauma, n (%)‡	48 (38.1)	933 (20.6)	<0.001*
Skull base fracture, n (%)	23 (18.3)	195 (4.3)	<0.001*
Neck seatbelt sign, n (%)	10 (7.9)	109 (2.4)	<0.001*
Hanging mechanism, n (%)	1 (0.8)	11 (0.2)	0.28
Cervical spine fracture, n (%)	52 (41.3)	299 (6.6)	<0.001*
LeFort II or III fracture, n (%)	8 (6.4)	33 (0.7)	<0.001*
Mandible fracture, n (%)	5 (4.0)	23 (0.5)	<0.001*
ISS, median (IQR)	18 (10–27)	9 (5–14)	<0.001*
Severe TBI or DAI, n (%)§	28 (22.2)	206 (6.4)	<0.001*
Length of hospital stay, median (IQR), d	7 (3–16)	3 (1–7)	<0.001*
Stroke, n (%)	10 (7.9)	7 (0.2)	<0.001*
Death, n (%)	16 (12.7)	90 (2.0)	<0.001*

*Statistically significant.
†Motorcycle crash, auto vs. pedestrian, or explosion.
‡Chest Abbreviated Injury Scale score of 3 or higher.
§Glasgow Coma Scale 8 or less upon arrival.
DAI, diffuse axonal injury; IQR, interquartile range; ISS, Injury Severity Score; SBP, systolic blood pressure.

grade 1, 2, 3, and 4 BCVI, respectively versus 29%, 19%, 24%, and 29% of patients in the *no treatment* group ($p = 0.25$). Treatment versus no treatment for individual grades of BCVI was primarily dictated by concomitant injuries such as additional BCVI or the presence of intracranial hemorrhage. Details, outcomes, and complications are shown in Table 4. Cervical spine, severe (LeFort II and III) facial, and skull base fractures were the three strongest predictors of BCVI with OR of 8.06 (5.35–12.13), 5.71 (2.16–15.12), and 2.67 (1.52–4.69), respectively (Table 5).

DISCUSSION

Almost three decades of research into BCVI have resulted in a solid understanding of its pathomechanism, natural course, and complications, allowing for the development and refinement of extensive screening criteria and treatment recommendations. Nevertheless, BCVI continues to "[…] represent a confusing group of injuries that lead to several quandaries in management" (Dr. Fabian, 2012 Scudder Oration on Trauma[17]).

In our study population of 4,659 adult blunt trauma patients at a level 1 trauma center, 2.7% had BCVI, with a high proportion of grades 2 and 3 injury. This is well within previously described ranges for the incidence of BCVI,[5,6,15,16,18–20] albeit on the higher end. It is also entirely consistent with the observation that the incidence of BCVI has been steadily increasing over the last decades because of improved imaging modalities and expanded screening criteria—the more we look, the more we find. Universal screening is a logical next step. We confirmed that established screening criteria fail to identify up to one third of patients with carotid or vertebral artery pseudoaneurysm and almost a quarter of all BCVIs grade 3 and higher. We directly evaluated the two most extensive and arguably widely used screening criteria in use in the United States—the expanded Denver criteria and clinical risk factors described in the ACS TQIP Best Practices Guideline in Imaging. The latter resembles the original Denver criteria and 2009 Western Trauma Association guideline,[21] the former represents the ones recommended in the current Scandinavian Neurotrauma Committee guideline.[22] We therefore offer a comprehensive evaluation of widely used current screening criteria; our results are similar to those reported in a recent European single-center study of 4,104 patients with BCVI incidence of 2.2%, and sensitivity of these clinical screening criteria ranges from 57% to 84%.[20]

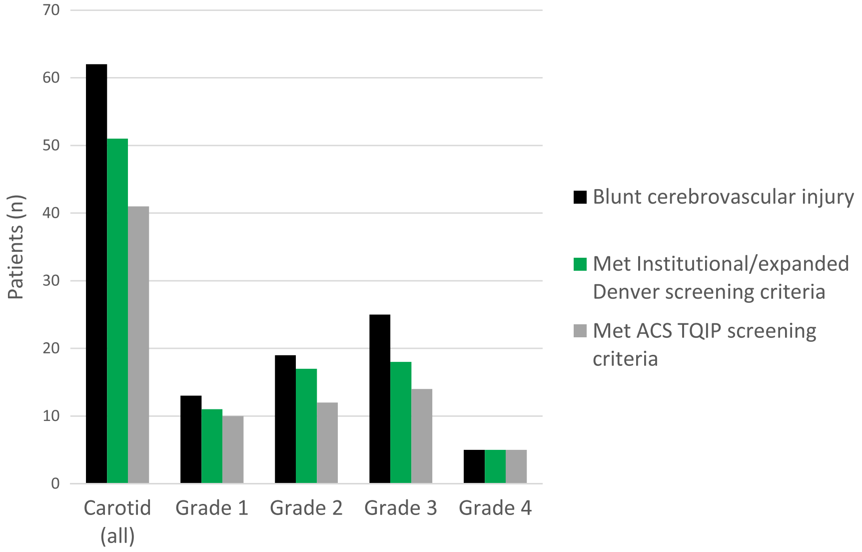

Figure 1. Incidence and detection rates of carotid artery injuries by grade.

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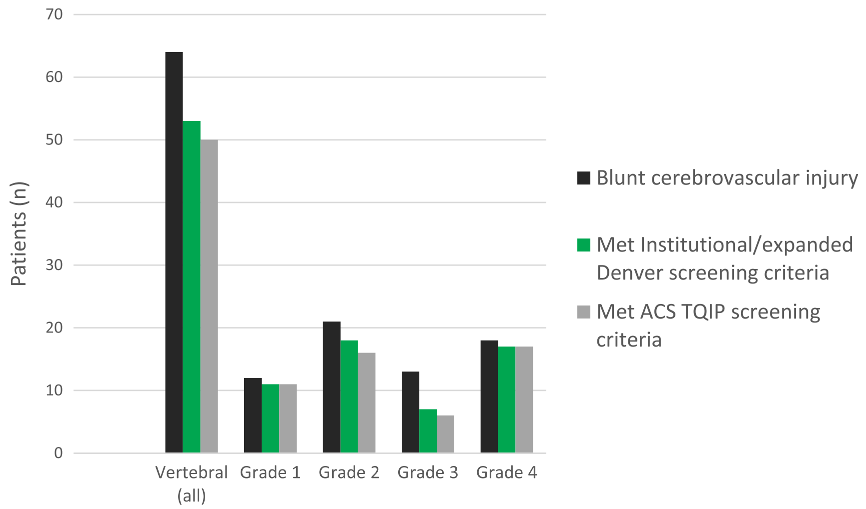

Figure 2. Incidence and detection rates of vertebral artery injuries by grade.

The systematic assessment and classification of BCVIs began with the trauma groups in Memphis[10] and Denver[11] in the 1990s. With digital subtraction angiography (DSA), an invasive and itself potentially harmful intervention[3] as the only reliable diagnostic modality, the identification of a narrow group of patients at high risk for this rare injury was critical. Until recently, CTA neck had limited sensitivity for BCVI compared with DSA,[3,15,23,24] but the advent of 64-slice (and higher) CT scanners has obviated the need for diagnostic DSA.[3,23]

Severe traumatic brain injury (TBI), skull or LeFort II and III facial fractures, and high cervical spine injury are well-established risk factors for BCVI, but 20% to 30% of patients with carotid or vertebral injury may not have any risk factors for BCVI.[1–3,9,16] Our analyses corroborate these findings, demonstrating that cervical spine, severe (LeFort II and III) facial, and skull base fractures are strong predictors of BCVI, but that even severe BCVI is not limited to this patient population. In addition, while most trauma centers use screening protocols based on Memphis or Denver criteria in general, there is a wide variety of institutional modifications,[9] making the systematic assessment of this injury difficult across multiple institutions. An ever-expanding list of risk factors (17 in our institutional protocol) also raises concerns about trauma teams' ability to consistently comply with all screening criteria in a busy trauma bay.

Universal screening for BCVI with a high-resolution neck CTA will invariably pick up questionable injuries. These equivocal findings represent a real challenge because they might lead to excessive additional diagnostic workup such as multiple CTAs or to overtreatment with antithrombotic medication exposing patients to the risk of bleeding. Our data demonstrate that follow-up CTA within 48 hours clarified most equivocal findings, with only 0.6% of neck CTAs remaining without a clear

TABLE 3. BCVI Details and Screening Sensitivity

	Patients With BCVI	Injured Vessels	Patients Who Met Institutional/ Expanded Denver Criteria	Patients Who Met ACS TQIP Criteria
BCVI (all)	126 (100)	158 (100)	104 (82.5)	91 (72.2)
Grade 1	25 (19.8)	43 (27.2)	22 (88)	21 (84)
Grade 2	40 (31.8)	47 (29.8)	35 (87.5)	28 (70)
Grade 3	38 (30.2)	43 (27.2)	25 (65.8)	20 (52.6)
Grade 4	23 (18.3)	25 (15.8)	22 (95.7)	22 (95.7)
Carotid (all)	62 (49.2)	81 (51.3)	51 (82.3)	41 (66.1)
Grade 1	13 (10.3)	27 (17.1)	11 (84.6)	10 (76.9)
Grade 2	19 (15.1)	23 (14.6)	17 (89.5)	12 (63.2)
Grade 3	25 (19.8)	25 (15.8)	18 (72)	14 (56)
Grade 4	5 (4)	6 (3.8)	5 (100)	5 (100)
Vertebral (all)	64 (50.8)	77 (48.7)	53 (82.8)	50 (78.1)
Grade 1	12 (9.5)	16 (10.1)	11 (91.7)	11 (91.7)
Grade 2	21 (16.7)	24 (15.2)	18 (85.7)	16 (76.2)
Grade 3	13 (10.3)	18 (11.4)	7 (53.9)	6 (46.2)
Grade 4	18 (14.3)	19 (12)	17 (94.4)	17 (94.4)

All results are presented as n (%).

TABLE 4. Treatment and Complications of BCVI

	Patients With BCVI				
	All	Progression	Stroke	Bleeding	Death
No treatment	21 (16.7)	0	1 (4.8)	0	11 (52.4)
Treatment (all)	105 (83.3)	4 (3.8)	9 (8.6)	5 (4.8)	5 (4.8)
Heparin drip*	16 (12.7)	2 (12.5)	2 (12.5)	2 (12.5)	—
Aspirin 81 mg	20 (15.9)	0	2 (10)	0	—
Aspirin 325 mg	57 (45.2)	1 (1.8)	2 (3.5)	1 (1.8)	—
Aspirin and clopidogrel	6 (4.8)	1 (16.7)	1 (16.7)	2 (33.3)	—
Home medication†	5 (4)	0	1 (20)	0	—
Procedural intervention	1 (0.8)	0	1 (100)	0	—

All results are presented as n (%).
*Partial Thromboplastin Time (PTT) goal 60 to 90.
†Coumadin or direct oral anticoagulant.

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TABLE 5. Risk Factors for BCVI

	Univariate Analysis (All $p \leq 0.2$)[1]	Multivariate Analysis*
Cervical spine fracture	10 (6.9–14.5)	8.1 (5.4–12.1), $p < 0.001$
LeFort II or III fracture	9.3 (4.2–20.5)	5.7 (2.2–15.1), $p = 0.001$
Skull base fracture	5 (3.1–8)	2.7 (1.5–4.7), $p = 0.001$
SBP 90 mmHg or less	4.5 (2.3–8.6)	2.2 (1–4.8), $p = 0.04$
Severe TBI or DAI†	4.2 (2.7–6.5)	2.1 (1.2–3.5), $p = 0.01$
Severe chest wall trauma‡	2.4 (1.7–3.4)	1.7 (1.1–2.5), $p = 0.02$
Neck seatbelt sign	3.5 (1.8–6.9)	—
Mandible fracture	8.1 (3–21.7)	—

*Odds ratio (95% confidence interval).
†Glasgow Coma Scale 8 or less upon arrival.
‡Chest Abbreviated Injury Scale score of 3 or higher.
SBP, systolic blood pressure; TBI, traumatic brain injury; DAI, diffuse axonal injury.

result regarding BCVI. In addition, these equivocal findings almost exclusively raised concern for grade 1 BCVI, which has a low risk for progression and complications. However, BCVI is not a static injury and even low-grade BCVI may well progress to higher stages. Described progression rates range from 10% to 30%, with grade 2 BCVI having the highest risk for progression,[13,25,26] making the identification of even low-grade BCVI necessary.

The use of CTA neck in every trauma activation to screen for BCVI may also raise concern about iatrogenic acute kidney injury). In trauma patients, the clear attribution of abnormally elevated creatinine to contrast-induced nephropathy as opposed to other etiologies including critical illness, severe trauma, or antibiotic administration is difficult. A thorough review of the nephrotoxic potential of IV contrast in the most recent American College of Radiology's Manual on Contrast Media suggests that its presumed risk is likely overstated.[27,28] Clinically, we considered the additional amount of contrast used for the CTA neck portion of a whole-body CT including CTA chest, which is standard in our trauma activations, to be of limited concern. This is supported by a review of our institution's ACS TQIP data, which demonstrated no increase of acute kidney injury when comparing its incidence in the 18 months before (1%) and 18 months after (0.8%) implementation of universal BCVI screening.

The practice of whole-body CT scanning for all major trauma activations remains debated but has been in place at our institution for several years before this study, in addition to being used in many hospitals across the country. It is primarily based on reviews of missed injuries in morbidity and mortality conferences and supported by evidence on the benefits of whole-body CT for all trauma patients.[29–32] Even minor trauma mechanisms such as falls from standing position can lead to severe injuries. Particularly elderly patients are at high risk for complications from spine and rib fractures,[33] represent a growing patient population in the United States, and constituted almost a quarter of our patient cohort. These patients often have substantial atherosclerosis and stenosis of the carotid and/or vertebral arteries, increasing their risk for BCVI and its complications.[34] While there are several studies and reviews that question the benefit universal whole-body CT scan for trauma activations,[35] this practice is generally supported in the most recent American College of Radiology's Appropriate Use Criteria of CT scans for major blunt trauma.[36] Therefore, a decision on this practice should be made in institution-specific practice protocols at trauma centers.

Antithrombotic medication is reported to dramatically decrease the rate of stroke from BCVI,[4,13,37,38] albeit not necessarily its progression.[25] In the most recent practice management guidelines of the Eastern Association for the Surgery of Trauma,[39] the benefit of antithrombotic therapy is described as a significantly decreased risk for stroke and mortality with ORs and confidence intervals of 0.20 (0.06–0.65) and 0.17 (0.08–0.34), respectively. A major concern with the use of antithrombotic therapy is a bleeding complication, but most studies demonstrate the safety of both anticoagulation with heparin and use of antiplatelet medication.[37,38] However, a comparison of treatment regimens across studies and institutions is difficult because there is no uniform approach to single versus dual antiplatelets, 81 mg versus 325 mg Aspirin, antiplatelets versus heparin drip, and Partial Thromboplastin Time (PTT) goals. There are even less data available on the use of direct oral anticoagulants in the treatment of BCVI. In our patient population, patients received 81 mg or 325 mg Aspirin for BCVI grades 1 and 2, and a heparin drip with Partial Thromboplastin Time (PTT) goal of 60 to 90, or dual antiplatelets for grade 3 BCVI. Because a single antiplatelet agent may not reliably result in effective antithrombotic action,[40] dual antiplatelets may increase although not guarantee reliable antiplatelet effect.[26,41] For grade 4 injuries (complete occlusion), neurosurgery advised on the usefulness of anticoagulation or antiplatelet agents on a case-by-case basis. Patients who did not receive treatment for BCVI did so primarily because of the presence of concomitant severe TBI (GCS, ≤8) with intracranial hemorrhage, which was more common in the no treatment than treatment group (38% vs. 19%, $p = 0.08$). A significantly larger number of patients in the "no treatment" group died from severe TBI (Table 4). However, because this study was not powered to compare complications between the different treatment regimens and because of the low incidence of BCVI-related complications, we are unable to draw statistically valid conclusions.

As a retrospective review of the trauma registry and the electronic medical records at a single institution, this study has inherent limitations. The exclusion of hemodynamically unstable patients who did not undergo CT scan upon arrival in the trauma bay may have resulted in selection bias. The assessment of outcomes and complications is limited because of low numbers and the confounding effect of associated injuries in patients with BCVI. In our patient population, patients with BCVI had significantly higher stroke (8%) and mortality rates (12.7%), but these patients also had a more severe burden of traumatic injuries (higher Injury Severity Score) and often severe TBI. A stroke was identified on admission imaging in 4 (40%) of 10 patients with BCVI, while a stroke occurred at a median of 3.5 days after admission in the other six patients. Not all patients with equivocal findings for BCVI on initial CTA neck received follow-up, either because they expired from other injuries, neurosurgery disagreed with the radiology read, or sometimes there was no discernible reason listed in the electronic medical record. Lastly, we were not able to assess the long-term outcomes of our patients with BCVI because of inconsistent follow-up.

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In summary, even an extensive list of risk factors for BCVI screening such as the evidence-based and refined expanded Denver criteria misses a significant proportion of patients with this potentially devastating injury. Generous CT imaging of hemodynamically stable blunt trauma patients has become the standard of care in most trauma centers, and modern CT scanners allow for the efficient and safe diagnosis of BCVI in these patients. While it may be possible to add even more risk factors to currently existing screening criteria, compliance with an exhaustive list of risk factors would likely decline and still never reach the (near) 100% sensitivity of universal screening. In our total patient population, 49% would not have undergone CTA neck because they did not fulfill expanded Denver screening criteria. In this group, the incidence of BCVI was 1.1%, that is, for every 1,000 patients undergoing CTA neck despite not fulfilling screening criteria, we would find 11 patients with BCVI.

A cost-benefit analysis could compare the treatment costs of BCVI complications such as stroke with the costs of imaging and possible iatrogenic complications of overtreatment to determine a financially acceptable screening guideline. At our institution, the cost of the CTA neck includes the cost for a CT c-spine, and a whole-body CT scan including CTA neck is only 7% more expensive than a standard whole-body CT. Most importantly, however, from a clinical perspective, universal screening offers substantial potential benefit and little harm. It should therefore be strongly considered for all major traumas with the exception of patient populations with higher-than-normal risk for CT scan-related complications (e.g., pregnant patients and children) or those with highly unlikely trauma mechanism such as isolated extremity injury.

AUTHORSHIP

S.W.L., D.B., and M.B.A. contributed in the study design. S.W.L., D.B., R. S., B.T., B.B. contributed in the data acquisition. S.W.L., D.B., B.T., S.J., E.R., M.B.A. contributed in the data analysis. S.W.L. and D.B. contributed in the initial drafting of the article. S.W.L., D.B., R.S., B.T., S.J., E.R., B.B., and M.B.A. contributed in the critical revisions.

DISCLOSURE

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CRITIQUE

Since the introduction of screening for blunt cerebrovascular injuries (BCVI), the who, how, and why have been debated. The "why"- to identify asymptomatic BCVI and initiate stroke-preventive therapy- is not supported by prospective randomized clinical trials, but existing retrospective data are compelling enough that screening is widely practiced and recommended.[1–3] And although the accuracy of CT angiography (CTA) is somewhat inferior to that of arteriography, it is the current accepted standard for "how."

The question of "who" has been debated since the introduction of screening in the mid-1990s. With arteriography as the only reliable diagnostic study, there was obvious interest in the "highest risk" factors. Five significant predictors were identified in 1999- but 20% of patients with BCVI had none of the 5 risk factors.[4] With the inculcation of noninvasive screening protocols over the years, the list of criteria continued to grow. Still, recent studies report that 20%-40% of patients found to have BCVI do not have one of the recommended screening criteria (and yet, curiously, they were screened…)[5]

In this paper, Leichtle et al report the results of a protocol of universal screening. The authors found that 17% of patients did not meet the most extensive current screening criteria. The 51% of patients with screening criteria had 83% of the BCVI, whereas the other 49% of patients harbored 17% of the BCVI. Nobody wants to miss the injury that causes a stroke- but with these diminishing returns, it gives one pause. A key finding is that the 14 patients who would have been missed by screening criteria, were all involved in motor vehicle crashes (MVCs). This makes sense, given that the pathophysiology of BCVI typically involves cervical hyperextension or acceleration-deceleration mechanisms. Given that MVC patients are generally reasonable candidates for whole-body CT, this is a population to consider for BCVI screening as well.

This issue will undoubtedly be further investigated; it remains to be seen whether screening actually becomes more universal.

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