Functional outcomes following blunt cerebrovascular injury

Jennifer M. DiCocco, MD, Timothy C. Fabian, MD, Katrina P. Emmett, MD, Louis J. Magnotti, MD, Ben L. Zarzaur, MD, MPH, Nickalus Khan, BS, Jayna M. Kelly, BS, *and* **Martin A. Croce, MD,** *Memphis, Tennessee*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this Journal-based CME activity for a maximum of *1 AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Credits can only be claimed online at this point.

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of *J Trauma Acute Care Surg* articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a 'commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12 months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff:

Ernest E. Moore, Editor: PI, research grant, Haemonetics. Associate editors: David Hoyt, Ronald Maier, and Steven Shackford have nothing to disclose. Editorial staff: Jennifer Crebs, Jo Fields, and Angela Sauaia have nothing to disclose.

Author Disclosures:

All authors have nothing to disclose.

Reviewer Disclosure:

The reviewers have nothing to disclose.

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $50.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

Submitted: February 7, 2011, Revised: December 13, 2012, Accepted: December 18, 2012.
From the Department of Surgery, University of Tennessee Health Science Center, Memphis, Tennessee.
The study was presented at the 41st annual meeting of the Western Trauma Association in Big Sky, Montana, on March 1, 2011.
Address for reprints: Timothy C. Fabian, MD, Department of Surgery, University of Tennessee Health Science Center, 910 Madison Ave, Suite 203 Memphis, TN 38163; email tfabian@uthsc.edu.

DOI: 10.1097/TA.0b013e318287800f

BACKGROUND: There has been much debate on whom to screen, how to screen, and how to treat blunt cerebrovascular injury (BCVI), but there has been little published on long-term functional outcomes following diagnosis and treatment of BCVI. This study was conducted to address those long-term outcomes.

METHODS: Patients with BCVI during a 53-month period ending June 2009 were identified. Charts were reviewed for demographics, associated injuries, treatments, strokes, and in-hospital mortality. Posthospital discharge follow-up was conducted. A structured telephone interview was performed using a functional independence measurement–functional activity measurement questionnaire consisting of 30 questions in seven categories (self-care, sphincter control, mobility, locomotion, communication, psychosocial, and cognitive). Each question was scored from 1 (requires full assistance) to 7 (fully independent). Outcomes were compared by type of BCVI, associated injuries, and stroke.

RESULTS: Two hundred twenty-two patients with BCVI were identified. Twenty-four patients died during their initial hospitalization, and an additional 11 patient died after hospital discharge. The 68 patients who completed the interview constituted our study population. Mean follow-up was 35 months. Of a possible 210 points, the mean total score on functional independence measurement and functional activity measurement was 186, 185, and 188 for all patients, carotid artery injuries, and vertebral arteries injuries, respectively. A significant difference was seen when comparing patients with and without strokes (173 and 189, respectively).

CONCLUSION: This is the first report of functional outcomes following BCVI. We found that carotid and vertebral artery injuries have similar functional outcomes. As would be expected, the development of stroke led to worse outcomes. This underscores the importance of early diagnosis and initiation of therapy. Prevention of stroke in patients with BCVI leads to near-normal functional outcomes. (*J Trauma Acute Care Surg*. 2013;74: 955–960. Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiologic/prognostic study, level III.

KEY WORDS: Blunt cerebrovascular injury; carotid artery; vertebral artery; functional outcomes.

Blunt cerebrovascular injuries (BCVI) were once thought to be rare; however, these injuries are now diagnosed in up to 2% of blunt trauma patients.[1–4] With the increasing recognition of these potentially devastating injuries, there has been much controversy regarding who should be screened, what is the best screening modality, and what is the optimal treatment for patients with BCVI. Previous work has identified patients at highest risk for BCVI who should undergo screening for BCVI and long-term stroke rates and mortality associated with the treatment of BCVI using a combination of medical and endovascular therapy.[2–5]

While mortality and stroke rates are certainly important outcome measures, long-term function impairment has the greatest impact on the ability of patients to return to their pre-injury work environment and quality of life. However, posthospital discharge functional outcomes of patients with BCVI have not been evaluated. The purpose of the current study was to determine the functional outcomes in patients with BCVI following hospital discharge in a large contemporary series of patients who underwent aggressive screening and treatment for BCVI.

PATIENTS AND METHODS

Following approval from the institutional review board at the University of Tennessee Health Science Center, patients with BCVI admitted to the Presley Trauma Center at the Regional Medical Center at Memphis from January 2005 to June 2009 were identified from the trauma registry and angiography logs. The Presley Trauma Center is a Level I center that serves the midsouth and encompasses an approximately 150-mile radius from Memphis, Tennessee. Medical records were reviewed for demographic information, type of BCVI (carotid or vertebral artery), associated traumatic brain injury, stroke rates, and mortality. During this period, patients were screened for BCVI if they had any one or more of the following risk factors: basilar skull fracture, Le Fort II or III fractures, any cervical spine fracture, neck soft tissue injuries, anisocoria, neurologic examination result inconsistent with radiologic findings, or any abnormality on computed tomography angiography.[3]

A structured telephone interview was conducted using a modified functional independence measurement and functional activity measurement (FIM/FAM) questionnaire. Interviews were conducted with the patients or the primary caregiver if the patient was unable to communicate over the telephone. Patients who completed this interview constituted our study population. The FIM/FAM consists of 30 questions in seven subcategories (self-care, sphincter control, mobility, locomotion, communication, psychosocial, and cognitive) and takes 35 minutes to 45 minutes to complete. The seven subcategories are grouped into two broad categories, namely, total motor and total cognitive function. Each question is scored from 1 to 7, for a maximum of 210 points. A score of 1 indicates that the patient requires total assistance to perform the specific activity, while a score of 7 indicates that the patient is fully independent and able to safely perform the task in a timely manner. Figure 1 displays a sample data collection sheet. Interviewers were instructed on specific questions to ask to determine a score for each activity or task. Patients were also asked if they have been diagnosed with a stroke since hospital discharge. Outpatient clinic notes were also reviewed to identify new strokes following discharge. The Social Security Death Index was queried to identify any outpatient deaths.

Statistical Analysis

Outcomes of the telephone interviews were compared by type of BCVI (carotid and vertebral artery injuries), occurrence of stroke, and associated traumatic brain injuries. The scores were compared in each of the seven categories as well as the total motor, total cognitive, and overall FIM/FAM scores. There is a ceiling effect with FIM/FAM tests (the test cannot distinguish among those with the highest scores); any patient who scored the maximum number of points, a score of 7 for each question within a specific subcategory, reached the ceiling.

Functional outcomes data collection

SELF CARE							
Feeding	1	2	3	4	5	6	7
Swallowing	1	2	3	4	5	6	7
Grooming	1	2	3	4	5	6	7
Bathing	1	2	3	4	5	6	7
Dress Upper	1	2	3	4	5	6	7
Dress Lower	1	2	3	4	5	6	7
Toileting	1	2	3	4	5	6	7
SPHINCTER CONTROL							
Bladder Control	1	2	3	4	5	6	7
Bowel Control	1	2	3	4	5	6	7
MOBILITY							
Bed/Chair Transfer	1	2	3	4	5	6	7
Toilet Transfer	1	2	3	4	5	6	7
Tub Transfer	1	2	3	4	5	6	7
Car Transfer	1	2	3	4	5	6	7
LOCOMOTION							
Walking/wheelchair	1	2	3	4	5	6	7
Stairs	1	2	3	4	5	6	7
Community Access	1	2	3	4	5	6	7
COMMUNICATION							
Comprehension	1	2	3	4	5	6	7
Expression	1	2	3	4	5	6	7
Reading	1	2	3	4	5	6	7
Writing	1	2	3	4	5	6	7
Speech	1	2	3	4	5	6	7
PSYCHOSOCIAL ADJUSTMENT							
Social Interaction	1	2	3	4	5	6	7
Emotional Status	1	2	3	4	5	6	7
Adjust to Limits	1	2	3	4	5	6	7
Employability	1	2	3	4	5	6	7
COGNITIVE FUNCTION							
Problem Solving	1	2	3	4	5	6	7
Memory	1	2	3	4	5	6	7
Orientation	1	2	3	4	5	6	7
Attention	1	2	3	4	5	6	7
Safety Judgment	1	2	3	4	5	6	7

Scale:
7 Complete Independence (timely, safely)
6 Modified Independence (extra time, devices)
5 Supervision (cuing, coaxing, prompting)
4 Minimal Assist (performs 75% or more of task)
3 Moderate Assist (performs 50%-74% of task)
2 Maximal Assist (performs 25% to 49% of task)
1 Total Assist (performs less than 25% of task)

Figure 1. Data collection sheet for functional outcomes.

The percentage of patients who reached the ceiling effect with and without ischemic strokes were compared in each of the subcategories. Data were analyzed with PASW 18.0 (IBM Corporation, Somers, NY) and SAS 9.2 (SAS Institute Inc., Cary, NC). Categorical data were analyzed with χ^2 tests, and continuous data were analyzed with Student's *t* tests or analysis of variance, whichever was appropriate. If continuous data were skewed, medians were compared using the Wilcoxon rank-sum test or the Kruskal-Wallis test. Any *p* value less than 0.05 was considered statistically significant.

RESULTS

Population Overview

During the 53-month study period from January 2005 to June 2009, 222 patients were identified with 263 BCVIs. There were 115 carotid artery injuries and 148 vertebral artery injuries identified. All patients underwent conventional angiography to confirm their injuries. A summary of the patient demographics and outcomes are presented in Table 1. The average age was 40 years, and 67% of patients were male. Motor vehicle collisions were the most common mechanism of injury (81%). There were 24 in-hospital deaths (11%), and 29 patients (13%) were found to have ischemic strokes at some point during their hospitalization. Of those with ischemic strokes, 17 patients (59%) had symptoms of ischemia or

TABLE 1. Summary of All Patients With BCVIs and the Study Population

	All BCVI (n = 222)	Study Patients (n = 68)
Patient characteristics		
Age, y	40 (15–93)	39 (15–69)
Male	148 (67)	38 (56)
Female	74 (33)	30 (44)
Race		
White	135 (61)	46 (68)
African American	82 (37)	22 (32)
Hispanic	4 (2)	—
Other	1 (1)	—
Injury mechanism		
Assault	5 (2)	3 (4)
All-terrain vehicle	1 (1)	—
Crush	1 (1)	—
Fall	11 (5)	3 (4)
Hanging	1 (1)	—
Motorcycle crash	9 (4)	5 (7)
Motor vehicle crash	179 (81)	54 (79)
Pedestrian struck	14 (6)	3 (4)
Injury severity		
ISS	28 (4–75)	28 (4–59)
Glasgow Coma Scale score at admission	12 (3–15)	12 (3–15)
Length of stay, d	20 (0–209)	19 (0–69)
Intensive care unit, d	13 (0–89)	13 (0–50)
Type of BCVI*		
Patients with carotid artery	93 (42)	29 (43)
Patients with vertebral artery	140 (63)	42 (62)
Outcomes		
Total strokes (including outpatient)	34 (15)	13 (19)

Number in parentheses represents percentage or range.
*Total is greater than 100% owing to patients with both carotid and vertebral artery injuries.

TABLE 2. Comparison of Functional Outcomes Following Carotid and Vertebral Artery Injuries

	Carotid Artery Injury (n = 29)*	Vertebral Artery Injury (n = 42)*
Self-care	45 (20–49)	45 (21–49)
Sphincter control	13 (10–14)	13 (2–14)
Mobility	25 (4–28)	25 (8–28)
Locomotion	18 (5–21)	18 (3–21)
Communication	31 (16–35)	33 (24–35)
Psychosocial	23 (13–28)	23 (7–28)
Cognitive	30 (13–35)	32 (20–35)
Total motor	101 (41–112)	100 (39–112)
Total cognitive	84 (45–98)	88 (51–98)
Overall	185 (95–210)	188 (126–210)

None of the values were statistically different.
*Three patients are represented in both groups owing to concomitant carotid artery and vertebral artery injuries.

radiologic findings of ischemia upon arrival to the hospital, and 5 patients (17%) developed symptoms before having their diagnostic angiography. The remaining seven ischemic strokes (24%) occurred among the 200 patients who were asymptomatic at the time of their diagnosis. Clinical follow-up was achieved in 85% of patients (169 of 198) who were discharged alive from the hospital.

In the patients who were alive at the time of discharge, an additional 11 deaths were identified in the Social Security Death Index following hospital discharge. Of the 187 survivors, 74 (40%) were contacted for telephone follow-up. Sixty-eight (92%) of those contacted completed the entire questionnaire. Mean follow-up was 35 months (range, 12–61 months). A comparison of all patients with BCVI to the study population (those that completed the telephone interview) is presented in Table 1. The 68 patients in the study population are similar to the overall BCVI population with regard to age, injury severity, and type of BCVI. Eight patients in the study population experienced an ischemic stroke at some point during their hospitalization (five on arrival to the hospital and three during their hospitalization). Five additional patients had been diagnosed with strokes since hospital discharge. Thus, the 13 patients with stroke lead to a 19% stroke rate in those that completed the telephone interview.

TABLE 3. Comparison of Functional Outcomes by the Presence or Absence of Associated Traumatic Brain Injury

	No Traumatic Brain Injury (n = 49)	Traumatic Brain Injury (n = 19)	*p*
Self-care	45 (21–49)	44 (20–49)	NS
Sphincter control	13 (2–14)	13 (6–14)	NS
Mobility	25 (8–28)	24 (4–28)	NS
Locomotion	18 (6–21)	17 (3–21)	NS
Communication	33 (21–35)	31 (16–35)	NS
Psychosocial	24 (7–28)	21 (13–28)	0.026
Cognitive	32 (20–35)	29 (13–35)	0.046
Total motor	101 (39–112)	97 (41–112)	NS
Total cognitive	88 (51–98)	81 (45–98)	0.027
Total FIM/FAM	190 (126–210)	178 (95–210)	NS

NS, not significant.

TABLE 4. Functional Outcomes in Patients Who Developed Ischemic Strokes Compared With Those That did not Develop Ischemic Strokes

	No Ischemic Stroke (n = 55)	Ischemic Stroke (n = 13)	*p*
Self Care	46 (20–49)	42 (21–49)	NS
Sphincter control	13 (2–14)	12 (6–14)	NS
Mobility	25 (8–28)	24 (4–28)	NS
Locomotion	18 (3–21)	18 (6–21)	NS
Communication	33 (16–35)	29 (21–35)	0.003
Psychosocial	24 (13–28)	21 (7–28)	NS
Cognitive	32 (13–35)	28 (20–35)	0.028
Total motor	101 (39–112)	95 (41–112)	NS
Total cognitive	88 (45–98)	78 (51–98)	0.009
Total FIM/FAM	189 (95–210)	173 (102–210)	0.044

NS, not significant.

FIM/FAM Outcomes

Of a possible 210 points, the mean total score for the entire study population on the FIM/FAM was 186. A comparison of patients with carotid artery injuries with those with vertebral artery injuries is presented in Table 2. There were three patients who had both carotid and vertebral artery injuries. The average score for patients with carotid artery injuries was 185, while patients with vertebral artery injuries

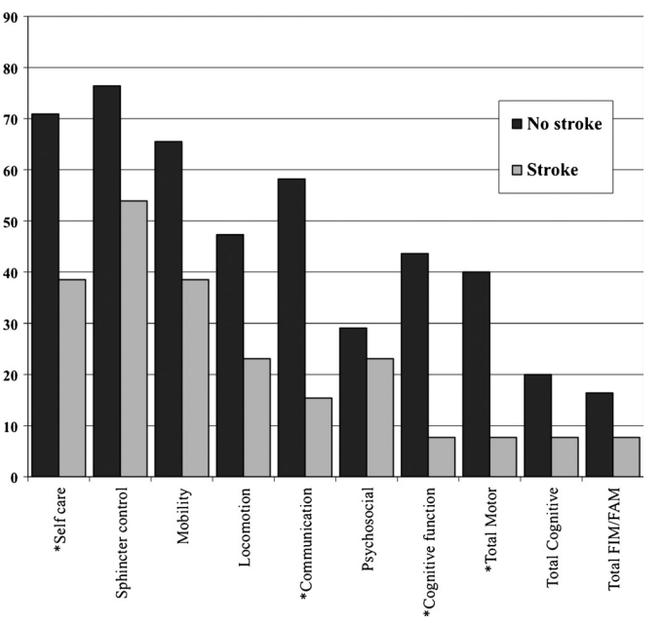

Figure 2. Percentage of patients with and without strokes reaching the ''ceiling'' or maximum score in each subcategory. The categories with an asterisk are statistically significant with a $p < 0.05$.

scored an average of 188. There were no significant differences in any category between patients with each type of BCVI. When the three patients with both carotid and vertebral artery injuries were compared with carotid only or vertebral only, there were still no differences.

To explore the influence of injuries associated with poor cognitive outcomes, we stratified patients based on the presence or absence of traumatic brain injuries. Traumatic brain injuries were associated with lower functioning in the areas related to cognitive functions, as presented in Table 3. When comparing the FIM/FAM score of the 55 patients who did not have ischemic strokes with the 13 who had strokes following BCVI, the overall FIM/FAM score was significantly different (Table 4). For the 13 patients with strokes, the mean overall FIM/FAM was 173 compared with 189 in those without ($p = 0.044$). Similar to those with closed head injuries, patients with ischemic strokes scored significantly worse in the cognitive subcategory ($p = 0.028$) and total cognitive ($p = 0.009$). Patients with strokes also performed worse in the communication subcategory ($p = 0.003$).

To determine which patients reached the maximum score on the FIM/FAM, we examined the percentage of patients with a score of 7 for every question within each subcategory and compared patients who experienced an ischemic stroke to those who did not. There was a lower percentage of patients with strokes who reached the ceiling in every category (Fig. 2). Patients who experienced ischemic strokes were significantly less likely to reach the best possible outcome for self-care, communication, cognitive function, and total motor functions ($p = 0.050$, 0.012, 0.023, and 0.047, respectively).

DISCUSSION

BCVIs are potentially devastating injuries, especially when the patient is young and develops an ischemic stroke. Our institution uses an aggressive approach to both the screening and treatment of patients with BCVI, including both anticoagulation and endovascular stenting of these injuries. This approach is associated with an improvement in stroke and mortality for patients at risk for BCVI.[1,4] Many institutions report between 10% and 33% stroke rates in patients who were initially asymptomatic.[4] None of those reports include outpatient follow-up. In this first report of functional outcomes following BCVI, we have shown that many patients are able to resume near-normal function after experiencing a BCVI. However, there are still a significant number of patients who are left with deficits in one area or another. Only approximately 20% of the study population reached the ceiling for the entire FIM/FAM, even when they had not experienced a stroke (Fig. 2). The most likely reason for this ongoing functional impairment may be associated injuries. These patients were severely injured polytrauma patients, as indicated by the average injury Severity Score (ISS) of nearly 30. However, owing to the small sample size in this study, we were unable to fully explore which of associated injuries may be contributing to poor functional outcomes.

There has been some debate in the literature regarding the relative severity or importance of carotid and vertebral injuries. Some have suggested that outcomes following vertebral BCVI are better than carotid BCVI. More recent data indicate that this may not be the case in in-hospital mortality and long-term stroke rates.[4] The results of the present study indicate that functional outcomes are also similar between carotid and vertebral artery injuries. Not surprisingly, the development of a stroke, however, significantly decreases the functional outcomes. This finding highlights the importance of prevention of ischemic stroke in this patient population via aggressive screening and treatment of patients with BCVI. We found in this study that there was still a significant number of patients who developed a stroke after their diagnosis, which underscores the need to continue to evaluate new treatment options for BCVI. In addition, the reason for outpatient strokes needs to be further delineated. One concern is that some patients may be noncompliant with antiplatelet medications following hospital discharge, leading to outpatient strokes especially in those treated with endovascular stents. Treatment of coronary stent patients with the antiplatelet combination of aspirin and clopidogrel for approximately 3 months until endothelialization occurs is required to reduce the risk of stent thrombosis. Although such data are not proven for stent treatment of BCVI, we believe dual antiplatelet therapy is similarly prudent in that situation. The average monthly cost of a daily dose of clopidogrel (75-mg tablet) is $225, which may lead to underuse by populations that are underinsured and financially challenged.

We acknowledge that there are limitations to this study. While we had clinical follow-up on 85% of patients, only 40% completed the in-depth telephone interview. It may be argued that we have missed outpatient strokes or not contacted the patients with the worst functional outcomes. This is a possibility; however, the cohort that was contacted seems to be representative of the original BCVI population, with similar age, injury severity, length of hospital stay, and types of injuries. In addition, we were able to contact a higher percentage of the patients who experienced strokes. This is likely because the patients who experienced complications or had poor outcomes were more likely to pursue follow-up opportunities and would be more likely to have valid contact information. Another important limitation is that functional outcomes are dependent on associated injures besides the BCVI.

There are many different tools available to measure functional outcomes including Glasgow Outcome Scale, the extended Glasgow Outcome Scale, Functional Assessment Measure, Functional Independence Measure, the combined FIM/FAM, and various quality-of-life scales such as the SF-36 and SF-12.[6] Each assessment tool has its own limitations. Edwards et al.,[1] assigned Glasgow Outcome Scale scores to patients with BCVI at the time of discharge and follow-up and found no differences based on the type of therapy given. The Glasgow Outcome Scale is a single score with 5 being "good recovery," 4 being "moderate disability," down to a score of 1, which is death.[7] This assessment tool is insensitive to small but clinically relevant changes, does not allow for discrimination in patients who have difficulty in specific areas but are otherwise high functioning, and has an even greater ceiling effect than the FIM/FAM.[6]

We chose the FIM/FAM to assess functional outcomes of rpatients because it encompasses several areas of potential disturbances after brain injuries, including communication,

motor function, behavior, and cognitive abilities. It has been shown to be a reliable assessment tool with internal consistency.[8] However, the FIM/FAM does have a ceiling effect as it cannot distinguish between a competitive athlete and someone who is able to ambulate fairly well without assistive devices, or between an astrophysicist and someone who can do basic problem solving. Another problem with this assessment tool is that others have not used this method of evaluating patients with BCVI, so comparisons to other institutions that use different treatment algorithms cannot be made.

While most publications on BCVI report on the outcomes of stroke and death, this is the first report of functional outcomes following BCVI. With nearly a 3-year follow-up, we found that most patients were able to return to near-normal functional abilities after BCVI. Carotid and vertebral artery injuries have similar functional outcomes. The greatest differences in outcomes were, not surprisingly, seen between the patients who had an ischemic stroke and those that did not. Therefore, efforts should be placed on prevention of stroke because this is a modifiable outcome and has the greatest impact on the functional outcomes of patients following BCVI. This underscores the importance of continued research for optimization of screening, diagnostic, and treatment protocols for BCVIs.

AUTHORSHIP

J.M.D., T.C.F ., L.J.M., and B.L.Z. designed the study. J.M.D., K.P.E., N.K., and J.M.K. collected the data, which J.M.D., T.C.F., K.P.E., L.J.M., B.L.Z., and M.A.C. analyzed. J.M.D. and K.P.E. wrote the manuscript, which J.M.D., T.C.F., and M.A.C. critically revised.

DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Edwards NM, Fabian TC, Claridge JA, Timmons SD, Fischer PE, Croce MA. Antithrombotic therapy and endovascular stents are effective treatment for blunt carotid injuries: results from longterm followup. *J Am Coll Surg*. 2007;204:1007–1013; discussion 1014–1015.
2. DiCocco JM, Fabian TC, Emmett KP, Zarzaur BL, Williams JS, Croce MA. Blunt cerebrovascular injury screening with 32-channel multi-detector computed tomography: more slices still don't cut it. *Ann Surg*. 2011;253: 444–450.
3. Emmett KP, Fabian TC, DiCocco JM, Zarzaur BL, Croce MA. Improving the screening criteria for blunt cerebrovascular Injury (BCVI): the appropriate role for computed tomography angiography (CTA). *J Trauma*. 2011; 70:1058–1065.
4. DiCocco JM, Fabian TC, Emmett KP, et al. Optimal outcomes for patients with blunt cerebrovascular injury (BCVI): tailoring treatment to the lesion. *J Am Coll Surg*. 2011;212:549–559.
5. Biffl WL, Moore EE, Offner PJ, Brega KE, Franciose RJ, Burch JM. Blunt carotid arterial injuries: implications of a new grading scale. *J Trauma*. 1999; 47:845–853.
6. Nichol AD, Higgins AM, Gabbe BJ, Murray LJ, Cooper DJ, Cameron PA. Measuring functional and quality of life outcomes following major head injury: common scales and checklists. *Injury.* 2011;42:281–287.
7. Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet*. 1975;1:480–484.
8. Hawley CA, Taylor R, Hellawell DJ, Pentland B. Use of the functional assessment measure (FIM+FAM) in head injury rehabilitation: a psychometric analysis. *J Neurol Neurosurg Psychiatry.* 1999;67:749–754.