Original Research Article

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An Analytical Study of Vascular Trauma in Traumatic Brain Injury

Shankar P.[1], Baskar A.R.[2]

Abstract

Introduction: "Traumatic brain injury (TBI) still represents the leading cause of morbidity and mortality in individuals under the age of 45 yrs." There is a large potential spectrum of traumatic vascular injury that may occur in isolation or in different combination. We analyze the various types of blunt cerebrovascular injury in thirty head injury patients. Blunt cerebrovascular injury (BCVI) may be overtly present in more than 1% of patients with blunt trauma.2 Aggressive screening strategies uncover injuries in up to 44% of those screened. If not appropriately diagnosed and treated in a timely manner, many such injuries are responsible for significant morbidity and mortality. *Aim of the study:* To analyze the various types of blunt cerebrovascular injury in head injury patients. *Materials and methods:* The patients admitted in the neurosurgical ward with vascular injury involving ICA, Vertebrobasilar artery and its primary branches as identified by CT brain, CT Angiogram, MRI scan, MR Angiogram or DSA either alone or in combination, were included in this study depending on the feasibility of investigation. *Results:* A total of 3770 head injury patients were admitted in Institute of Neurosurgery during the study period. Based on DENVER'S screening criteria about 95 patients were identified as high risk individuals for blunt cerebro vascular injury. Out of these 95 patients only 30 patients were diagnosed and confirmed to have vascular injury by CT angiogram, DSA and through post mortem. *Conculsion:* Our conclusions are Patients presenting with Raccoon eye (black eye), anterior skull fracture in sagital direction with CT brain findings suggestive of ischemia in the MCA/ACA territory were more likely to have supra clinoid ICA injury, Patients with Battle's sign, petrous bone fracture in transverse axis and CT brain showing features of ischemia were more likely to have ICA injury, Patients with Battle's sign, occipital bone fracture extending into the petrous part of temporal bone were more likely to have bilateral ICA or Vertebra basilar artery injury.

Keywords: Traumatic Brain Injury; Blunt Cerebrovascular Injury; Head Injury.

Introduction

"Traumatic brain injury (TBI) still represents the leading cause of morbidity and mortality in individuals under the age of 45 yrs." There is a large potential spectrum of traumatic vascular injury that may occur in isolation or in different combination. Common forms of vascular injuries are injury to intra parenchymal blood vessels. They may be 1. Focal vascular injury such as contusion, intracerebral hemorrhage or sub arachnoid hemorrhage, 2. Multifocal vascular injury which includes a combination of above mentioned injuries, or 3. Diffuse vascular injury such as petechial hemorrhage or micro hemorrhage. Injury to extra parenchymal blood vessels may include 1.Injury to bridging vessels such as acute subdural haematoma and chronic subdural haematoma, 2. Injury to meningeal artery and vein such as extradural haematma, and 3.Injury to venous sinuses such as extradural haematoma (EDH). The occult forms of vascular injuries are the blunt cerebrovascular injuries (BCVI) to the large arteries in the neck, internal carotid artery (BCI), vertebral artery (VBI), injuries to blood vessels in the circle of Willis and anterior, middle and posterior cerebral arteries and the basilar artery.

BCVI's are generally considered to be relatively uncommon; but carry a high rate of mortality and morbidity if they remain undetected. BCVI's

Author's Affiliation: [1]Assistant Professor, Department of Neurosurgery, Mohan kumaramangalam Medical College and Hospital, Salem, Tamil Nadu 636030, India. [2]Assistant Professor, Department of Neurosurgery, Stanely Medical College, Chennai, Tamil Nadu 600001, India.

Corresponding Author: Baskar A.R., Assistant Professor, Department of Neurosurgery, Stanely Medical College, Chennai, Tamil Nadu 600001, India.

E-mail: baskardrr@gmail.com

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may or may not initially present with symptoms or signs that warrant suspicion of such injuries and therefore the provision of adequate screening criteria, diagnostic investigations and management is crucial. The realization of this fact led to increased awareness of the amplitude of such injuries and the need to establish adequate screening criteria and cost-effective screening modalities. Such Injuries include thrombosis, dissection, subintimal hemorrhage, laceration and arteriovenous fistula. Dissections of the carotid or vertebral arteries in the neck sometimes may occur as a result of trauma. In such dissecting injuries intima of the vessel found injure. This intimal injury occurs due to the strangulation or whiplash mechanisms produced in trauma. This injury may cause stroke in the affected individual. Most of the dissection injury of carotid found just proximal to the site where it enters the petrous bone at the level of C1-C2. Pseudoaneurysm that develops after trauma may also found in intracranial vessels following trauma. These aneurysms may not have to be located at more typical locations like that of nontraumatic aneurysms around the circle of Willis. Subarachnoid hemorrhage occurring secondary to rupture of pseudo aneurysm may produce vasospasm in these vessels.

Carotid cavernous fistulas (CCF) that occurs after TBI, usually occurs as a result of injury to the carotid artery at the level of the cavernous sinus. It produces a high flow arterial venous shunt and often results in painful unilateral pulsating exophthalmos. And there will be increased flow in a retrograde direction in the superior ophthalmic vein. Patients with CCF may end up with loss of vision. Sometimes this arterial venous shunt can extend into the inferior pertrosal sinus and into the cortical veins of the cerebellum to produce hemorrhage.

Materials and Methods

The study was conducted at the Institute of Neurosurgery, Madras Medical College from January 2015 to January 2016. The aim of the study was to analyze the various types of blunt cerebrovascular injury in head injury patients. We included the patients with blunt cerebro vascular injury associated with traumatic brain injury. We excluded the patients with focal, multifocal and diffuse brain injury in the absence of findings suggestive of major vascular injury were excluded from this study. Patients not consenting for further investigations and treatment, patients who are not willing to take part in the study.

The patients admitted in the neurosurgical ward with vascular injury involving ICA, Vertebrobasilar artery and its primary branches as identified by CT brain, CT Angiogram, MRI scan, MR Angiogram or DSA either alone or in combination, were included in this study depending on the feasibility of investigation. But the minimum requirement for inclusion of this study was CT brain. In the event of death, of patients with CT brain alone, patient's post mortem findings were included in the data., All the factors associated with the trauma like age, sex, mode of injury, mechanism of injury, duration since injury, clinical features, treatment history were recorded and analysis was done.

Results

A total of 3770 head injury patients were admitted in Institute of Neurosurgery during the study period. Based on DENVER'S screening criteria about 95 patients were identified as high risk individuals for blunt cerebro vascular injury. Out of these 95 patients only 30 patients were diagnosed and confirmed to have vascular injury by CT angiogram, DSA and through post mortem. These 30 patients were studied in detail in this study and the following observations were made. Motor vehicle collision was the most common mode causing traumatic cerebrovascular injury accounting for 66.6% of the total cases studied. Almost all the injured individuals did not wear a helmet (93%). Among the study population males constituted (77%) and females (33%).

Incidence of BCVI was more in the younger age group than in elderly. More number of cases was reported in the 15–30 years age group accounting for 33%. Flexion and hyperextension mechanism was found to be the most common mechanism causing vascular injury (50%). 53% of the patients presented with ear bleed and it was the most common presenting symptom found among the 30 patients, followed by nasal bleed which was found in 36% of cases. Black eye (Raccoon eye) was found in 43% of cases with skull base fracture. Whereas 50% of case with temporal bone fracture presented with Battle's sign. Leforte's III fracture was the most common associated injury found in intra dural ICA injury i.e. 75%. Vertebrobasilar artery injury was found mostly in patients with cervical spine injury. Fracture involving the frontal bone extending into the anterior clinoid process was found in most of the ICA injuries (55%), followed by fracture of petrous part of temporal bone (38%). Fractures involving the occipital and petrous part of temporal bone most commonly resulted in common carotid (66%) and Vertebrobasilar artery injuries (100%). Skull base was found to be the most common fractured part in almost all the cases presented with features of vascular injury (100%). Among the vessels, ICA was the most common vessel found injured (77%) followed by CCA (10%) and VBA (17%). Intra dural part of ICA was more commonly injured (78%) than extra dural ICA.

Table 1: Glascow Coma Scale Distribution at the Time of Admission.

GCS	<4	5-6	9-13	14-15
n-30	14	12	2	2

Table 2: Site of bone fractures in thirty patients.

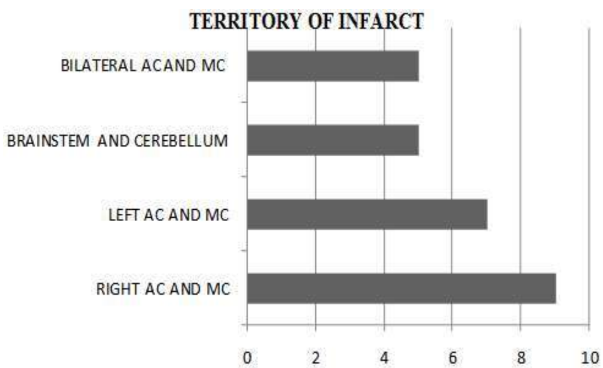

Chart 1: Territory of Infarct in thirty patients

Skull bone fracture	Frontal bone	Temporal bone	Occipital bone	Leforte's fracture	Skull base fracture
n=30	11	11	8	21	30

Table 3: Vessels Most Commonly Injured in thirty patients.

Injured Vessels	ICA	Vertebrobasillar	CCA
n=30	22	5	3

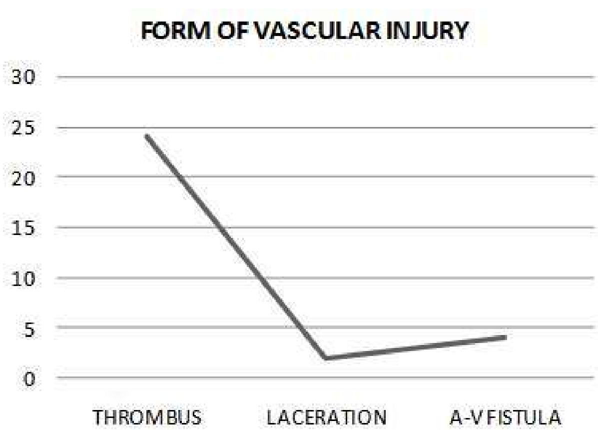

Chart 2: F The form of vascular Injury

On imaging studies, SDH was found in 50% of cases, followed by contusion in 16% of cases. Right side ACA& MCA territory was found involved in 70% of patients who presented with CT features of ischemia as against (64%) on left side. 80% of the injured vessels were found to harbor a thrombus followed by A-V fistula which was found in 13% of cases. Put together the intra cranial part of the major vessels were most commonly found injured (90%) than the extra cranial part of the vessel (10%).

Coming to the treatment part, since most of the deceased individuals reached the hospital after a delay of 6 hours following injury and also presented with low GCS and severe associated injuries, early investigations and intervention could not be done in all the patients. Of the 30 patients, 15 patients were treated with decompressive craniectomy. We were able to do definitive management in only 4 cases; the remaining patients were treated conservatively. Four patients presented with features suggestive of CCF. All the 4 patients underwent DSA to confirm the CCF and were treated with intraarterial embolization. Among them, 3 patients survived and one patient expired due to intra operative complication (bleeding). Among the 30 suspected vascular injury patients, we were able to identify vessel injury only in 9 cases in the ante mortem period while in the remaining 21 cases vessel injury was found and confirmed during autopsy. Among the 30 patients with vessel injury only 9 (30%) patients could overcome the illness while remaining 21 (70%) patients succumbed to the injury.

Disscussion

Blunt cerebrovascular injury (BCVI) may be overtly present in more than 1% of patients with blunt trauma [2]. Aggressive screening strategies uncover injuries in up to 44% of those screened. If not appropriately diagnosed and treated in a timely manner, many such injuries are responsible for significant morbidity and mortality. Aggressive screening protocols are now feasible using newer generation, multidetector helical scanners capable of detecting small intimal defects in a relatively non-invasive manner. Moniz1 performed the first cerebral angiogram in 1927. Since that time, neurovascular imaging has undergone rapid evolution. The introduction of computed tomography (CT) and magnetic resonance imaging (MRI) offered viable noninvasive means of imaging the neurovascular tree. More recently, improvements in technology and technique have enabled the acquisition of direct and indirect hemodynamic measurements and functional and physiologic data, as well as visualization of intravascular pathology.

Abdullah Al-Harthy et al. [3] revealed that treatment has focused on reducing the atheroembolic tendency of the disrupted vessel wall. Anticoagulation with heparin and anti-platelet agents has been used for this purpose, however, in a multitrauma patient, the risks of bleeding and the need for immediate surgery must be taken into account. Certain injuries to cervical vessels may be amenable to endovascular therapy. Therefore a multi-disciplinary team consisting of the emergency physician, trauma surgeon, vascular surgeon, neurosurgeon, interventional radiologist and intensivist is recommended for immediate and follow-up care. A high index of suspicion and maintaining aggressive evaluation protocols for patients with possible BCVI will definitely avoid diagnostic delay and may improve the overall outcome after BVI. Further research into optimal treatment strategies is warranted. Berne JD et al. [4] observed that aggressive screening protocols based on mechanism of injury, associated injuries, and physical findings are justified to minimize morbidity and mortality. Head and chest injuries may serve as markers for blunt cerebrovascular injury. Most deaths are directly attributable to the blunt cerebrovascular injury.

Biffl WL [5] and his colleagues studied thirty-seven patients with BCI and concluded that screening allows the identification of asymptomatic BCI and thereby facilitates early systemic anticoagulation, which is associated with improved neurologic outcome. The role of endovascular stents in the treatment of blunt traumatic pseudo aneurysm remains to be defined.

Miller PR and his colleagues 6 said that aggressive screening of patients with blunt head and neck trauma identified an incidence of BCVI in 1.03% of blunt admissions. Early identification, which led to early treatment, significantly reduced stroke rates in patients with BVI, but provided no outcome improvement with BCI. More encompassing screening may be required to improve outcomes for patients with BCI. However, less-invasive diagnostic techniques computerized tomographic angiography (CTA) and magnetic resonance angiography (MRA) are inadequate for screening. Technological advances are necessary before abandonment of conventional angiography, which remains the standard for diagnosis.

Kerwin AJ et al. [17,16] did a study over the 18-month period and concluded that liberalized screening criteria used in their study were appropriate to identify patients with BCI/BVI. This study suggests BCI/BVI to be more common than previously believed and justifies that screening should be liberalized.

Christian-Andreas Mueller, et al. [8] said that, in patients with cervical spine fractures or dislocations crossing the course of the vertebral artery, BVI are relatively frequent and may be associated with significant morbidity and mortality. BVI were identified by Digital Subtraction Angiography (DSA) in 27.5%. Despite anticoagulation therapy, 5.8% became clinically symptomatic and 2.9% died due to cerebrovascular ischemia.

Walter L. Biffl, MD et al. [9] said that, routine follow-up arteriography is warranted in patients with grade I and II BVIs because most of these patients (61% in their series) required a change in management. A prospective randomized trial will be required to identify the optimal treatment of BVI. In the literature reviewed, 10 there are only two prospective studies comparing single-slice computed tomographic angiography (CTA) and magnetic resonance angiography (MRA) to DSA which were done by the Denver and Memphis groups. In their studies, CTA had a sensitivity of 47–68% and a specificity of 67–99%. CTA missed 55% of Grade I, 14% of Grade II, and 13% of Grade III injuries. The authors concluded that CTA should only be used to diagnose BCVIs when DSA is not available. However, it is important to note that the CTA scanners used at that time were single slice CTAs, which along with other limitations such as timing contrast injection, image acquisition protocols, post-image processing delays (reformatting process), and inexperience with interpretation, might have accounted for the disappointing results in these two studies.

In terms of human sufferings, medical expenses and lost productivity, head injury is one of the major health care problems in India. Motor vehicle collisions account for most of the traumatic brain injuries. Cerebral blood flow is an important predictor of outcome in terms of mortality and morbidity after traumatic brain injury and if it is inadequate the outcome will be worse than expected. Blunt Cerebrovascular Injury (BCVI) to the Carotid and Vertebrobasilar arteries can occur in the setting of head and neck trauma when high-speed deceleration results in neck hyperextension and/or hyper flexion. Approximately 1 in 1000 blunt traumas results in BCVI. Although BCVI incidence is low, the sequelae are devastating with some authors reporting 80% of the cases were associated severe morbidity and with mortality up to 40%.

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Conclusion

Based on the above observations, the following conclusions could be made:

1. Patients presenting with Raccoon eye (black eye), anterior skull fracture in sagital direction with CT brain findings suggestive of ischemia in the MCA/ACA territory were more likely to have supra clinoid ICA injury.

2. Patients with Battle's sign, petrous bone fracture in transverse axis and CT brain showing features of ischemia were more likely to have ICA injury.

3. Patients with Battle's sign, occipital bone fracture extending into the petrous part of temporal bone were more likely to have bilateral ICA or Vertebra basilar artery injury.

Hence, I believe and conclude that the aforementioned observations found in this study could alert and suggest the surgeon to look for the most likely /specific vessel that could be injured in the given setting and he/she could proceed with the necessary investigations and treatment as early as possible. Larger sample size and studies from many more centers will be required to strongly validate these findings.

Source of suppourt: Nil

Conflict of interest: None

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