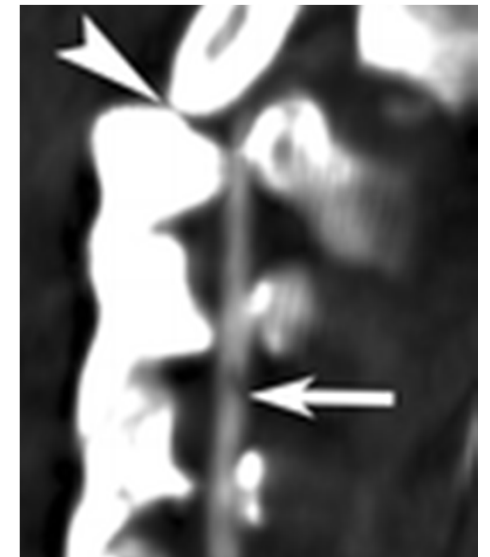
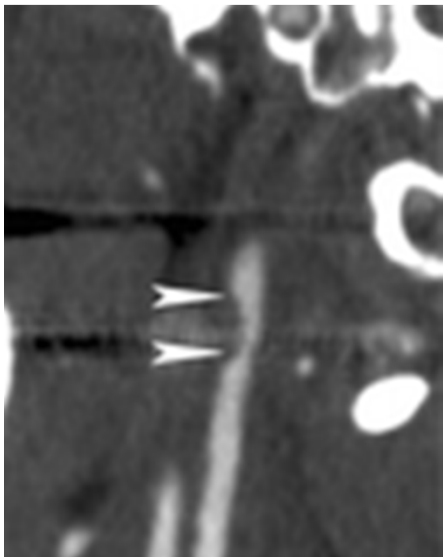




# Traumatic Carotid and Vertebral Artery Injuries

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# 10-Year Retrospective Analysis of Clinical and Radiographic Outcomes Following Traumatic Carotid and Vertebral Artery Injuries from a Level 1 Trauma Center





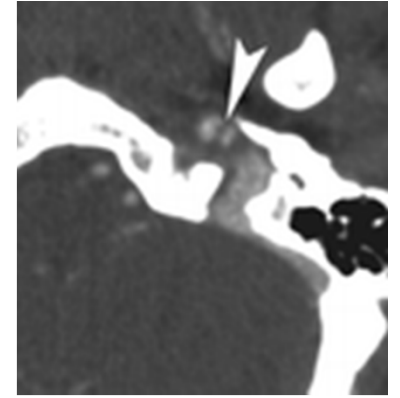
## Blunt cervical vascular injury

**Screening** of blunt carotid and vertebral artery injuries (BCVI) has **increased** since research has shown that these injuries are **more prevalent** than originally reported.

... has led to an **increased detection rate of 0.7%** in patients with blunt trauma.



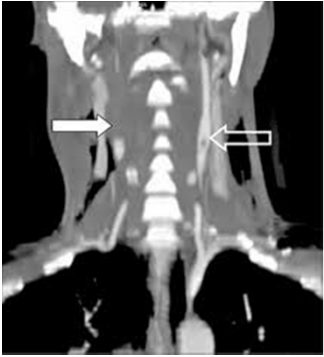
# Blunt cervical vascular injury



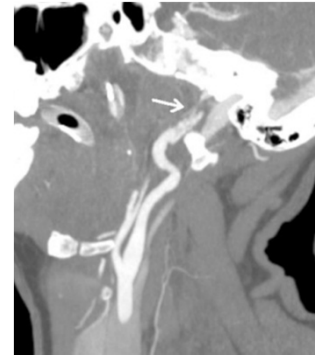
**Management** of these injuries remains heavily debated, but **anti-platelet** or anti-coagulant medications *tend to be first line treatments*.

*–Endovascular treatment has typically been reserved for symptomatic or certain higher-grade injuries.*

**Treatment** is based on the **concern** that emboli *may* originate from these injuries, posing a **risk** for cerebral infarction.

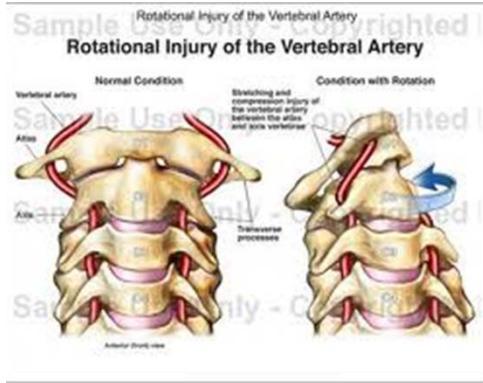


## Blunt cervical vascular injury



Although DSA is considered a gold standard for cerebral vascular imaging, ***CTA has become the preferred imaging modality for screening these traumatic vascular injuries.***

–...it is much **quicker, safer, and less expensive.**



# Grades of injuries

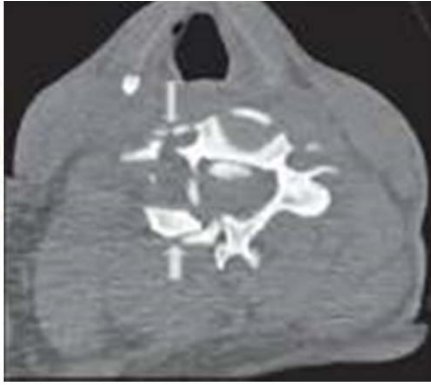


- .Grade 1** injuries are defined as a vessel lumen stenosis of less than 25%.
- .Grade 2** injuries are defined as a stenosis of the vessel lumen between 25 - 50%.
- .Grade 3** injuries defined as stenosis of the vessel greater than 50%, or the development of a pseudoaneurysm.
- .Grade 4** injuries are defined as vessel occlusion.
- Grade 5** injuries (*complete transection of the artery*).

# Blunt cervical vascular injury

- Biffi et al (2001-2002)**; Reported **BVI stroke rates of 3-44%**, and **BCI stroke rates of 19-40%**. Those that suffered a post-traumatic stroke, **90% of infarctions were noted prior to any medical treatments**, 9% were identified while individuals were on ASA and 1% occurred while on heparin.
- Miller et al (2002)**; Determined that **ischemic stroke from BCVI was eliminated by the use of ASA**.
- Cothren et al (2009)**; Evaluated patients with BCVI. The majority of patients in this cohort (49%) were treated with heparin, 23% were treated with either ASA or a combination of ASA and clopidogrel, and 28% were untreated. This study concluded that there was **no reliable way to alter the progression of injury**.
- Eastman et al (2009)**; Reported a **BCVI stroke rate of 1/26 (3.8%)**. The cerebral infarction in this study was identified in a patient with a grade 3 BVI.
- Griessenauer et al (2013)**; Outcomes of 112 patients with BCVI. Included both carotid and vertebral artery injuries of various grades, and identified only one case of ischemic stroke caused by BVI. Concluded most **ischemic strokes occur before initial screening with CTA and treatment with an anti-platelet medication**, indicating that follow-up **imaging will not aid in preventing most ischemic strokes**.





# Screening protocols

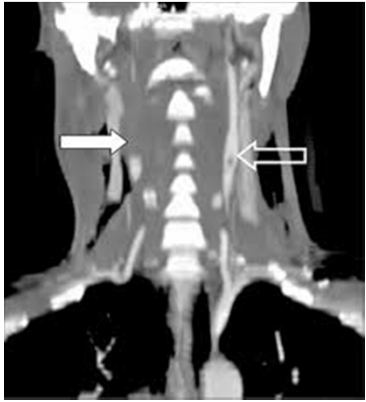


**Screening** for blunt cerebrovascular injuries occurs through a modification of the Denver Criteria.

**Any patient with:**

- Cervical spine fractures of the vertebral body or pedicle.
- Basilar skull fractures involving the carotid canal or petrous bone.
- LeFort II or III fractures.
- GCS <7 without obvious cerebral injury on head CT and/or near hanging/strangulation with a ligature mark/contusion.
- >>***Receives a screening cervical CTA to rule out a vascular injury.***





# The Carotid and Vertebral Artery Injury Survey



**Retrospective** review of a prospectively maintained database of all traumatic cervical vascular injuries was conducted at our Level I Trauma Center (Parkland Memorial Hospital, Dallas, TX).

.August 2003 through April 2013.

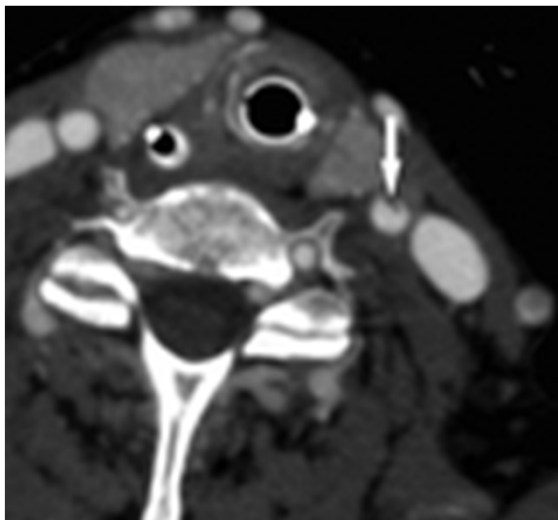
.Attention focused on blunt BCIs and BVIs.

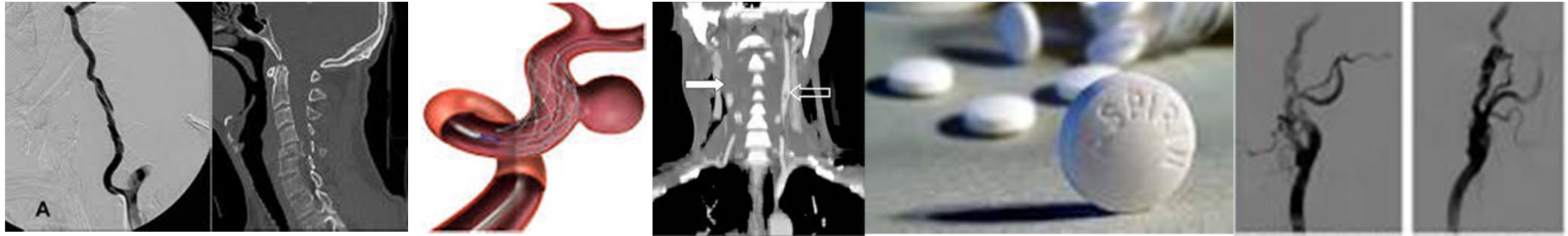
.*Penetrating injuries not included.*

# Goals of the study

***Imaging, progression and clinical and radiographic outcomes*** of grade 1-4 BVIs and BCIs were analyzed.

- To gain a better understanding of the **natural history** and **evolution** of these injuries and,
- To **establish a rational management plan** based upon their progression and risk of infarct.





**Data** including age, sex, mechanism of injury, presence or absence of a cervical fractures, and other traumatic injuries within the proximity of the neck.

**Radiographic imaging** was reviewed (e.g. CT angiography (CTA), digital subtraction angiography (DSA)).

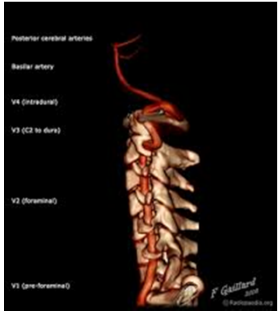
–As was the number of images performed per individual,

–the length of time between imaging,

–and radiographic outcomes at the end of follow-up.

**Treatment(s)** provided was recorded (e.g. anti-platelet, anti-coagulant, no treatment, *etc.*).

The **incidence of stroke** was recorded as confirmed by clinical presentation and neuroimaging.



# Results – Grade 1-2 BVI

**187 grade 1 or 2 BVI in 143 patients.**

•Comprised 35% of all blunt cervical vascular injuries and 63% of all vertebral injuries.

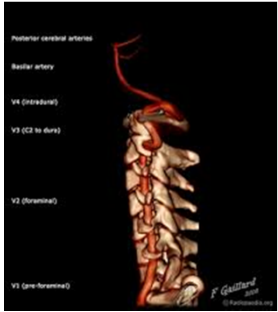
•Of these 143 patients, 120 were available for follow-up with **152 grade 1 or 2 BVIs** available for final analysis.

•**23 patients excluded:** 6 died from other trauma-related injuries and **17** lost to follow-up.

79 patients (**57.5%**) were **male**.

•**Mean age:** 36.1 years (range, 14 to 87 years).

•**Mean follow-up:** 40 days



# Results – Grade 1-2 BVI

**Mechanism of injury** was MVC in 80 patients (67%), fall in 23 patients (19%) and MCC in 9 patients (8%).

*Less common:* assault, all-terrain vehicle (ATV) accidents and motor pedestrian collisions (MPC) in the remaining 8 patients (7%).

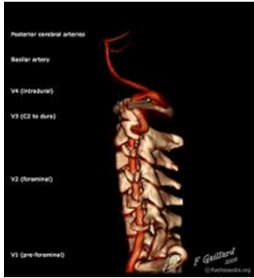
**62 patients (52%) had a single-sided grade 1 or 2 BVI.**

58 patients (48%) presented with multiple cervical vascular injuries.

**CTA** was used as the initial imaging modality in **99.2% of cases**

•118 patients (98%) received two or more CTA scans, with a mean CTA per patient of 2.6.

•DSA was performed in 8.3% of cases



# Results – Grade 1-2 BVI

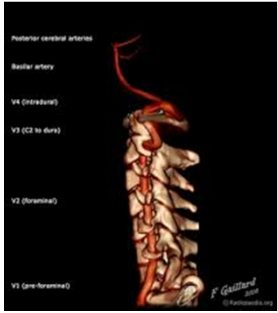
**Repeat imaging** showed 143 (**94%**) of the 152 injuries were ultimately **stable, improved or resolved**, as determined by their last follow-up imaging.

•Specifically, **20%** (29 injuries) remained unchanged, **10%** (15 injuries) improved, and **70%** (99 injuries) completely resolved on final imaging.

•There were **9** grade 1 or 2 BVI cases (6%) that were considered ***unstable*** - defined by a worsening grade of injury on 1<sup>st</sup> f/u imaging.

•**2** showed subsequent improvement, and in **3** cases the injury completely resolved.

•Only **4** cases (2.6% of the total follow-up group) demonstrated **progressive worsening** of their vascular injury ***without*** subsequent radiographic improvement.



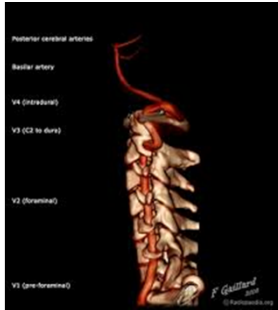
## Results – Grade 1-2 BVI

79 patients (**66%**) were treated with **aspirin (ASA)** alone.

.3 were treated with heparin and later transitioned to Coumadin, 1 was treated with Coumadin alone, 1 was treated initially with ASA and then transitioned to heparin and subsequently to ASA and clopidogrel and 1 was treated with clopidogrel alone.

35 patients (**33%**) were ***not treated with any medication.***



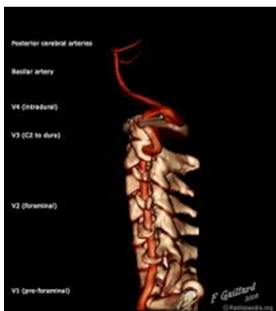


## Results – Grade 1-2 BVI

**2 cases** (1.7 % of the follow-up group) had posterior circulation infarcts felt related to their BVI.

**Case 1:** 18 y/o male , MVC, C2 Hangman's fx involving bil transverse foramen, started on ASA, had ***asymptomatic*** hypodensity within the right cerebellar hemisphere seen on a routine head CT on HD 2.

**Case 2:** 63 y/o female, MVC, C2 Hangman's fx involving bil transverse foramen, started on ASA. On HD 4 had new onset confusion and receptive aphasia, MRI demonstrated scattered posterior circulation infarcts. Medical management was changed to heparin with subsequent transition to ASA and clopidogrel. ***Her symptoms resolved shortly thereafter.***



## Results – Grade 1-2 BVI

**.Case 2:** ...63-year-old female with scattered posterior circulation infarcts whose symptoms resolved.

–**complicated PMH**, prior cerebral infarctions, old cerebellar lacunar infarcts. Had undergone mid-basilar stent placement earlier that year, as well as partial coiling of a basilar apex aneurysm (which was also found to contain a small thrombus on vascular imaging).

**.If** this later case is determined to be **unrelated** to the BVI secondary to the aforementioned posterior circulation disease, the incidence of post-traumatic cerebral infarction in this low-grade BVI group **decreases to 0.8%**.

**.Including the LTF group, further drops to 0.7%**



## Conclusions – Grade 1-2 BVI

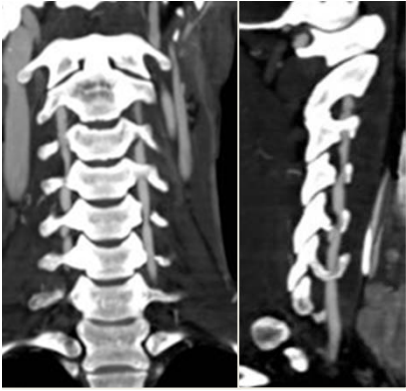
*The majority of low-grade BVIs remain stable or improved at final follow-up.*

*Cerebral infarction rate of 1.7% may be over-estimated.*

*.May be closer to 0.7%.*

Additional cervical vascular injuries **did not** correlate with worsened outcome.

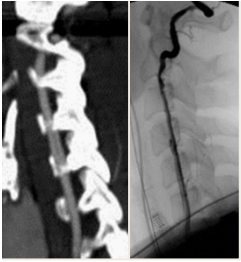
Progressive worsening of the vascular injury *without* subsequent radiographic improvement (2.6% of cases) **did not** correlate with adverse clinical outcome.



## Conclusions – Grade 1-2 BVI

The **use of ASA** or other anti-platelet or anti-coagulant medication in the low-grade BVI cohort ***did not*** correlate with radiographic injury stability ***nor*** with a decreased rate of cerebral infarction.

The ***time and cost*** allotted for follow-up imaging low-grade BVI deserves attention, as it may not be entirely necessary.



## Conclusions: Grade 3-4 BVI

*The majority of high-grade BVIs remain stable or improved at final follow-up.*

Despite a **4% rate of radiographic worsening** in the grade 3 BVI group and a **35% recanalization rate** in the grade 4 BVI group, there were no adverse clinical outcomes associated with these radiographic changes.

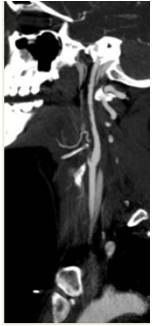
No cerebral infarctions were noted in the grade 3 group.

A **7% stroke rate** was identified in the **grade 4 BVI group**; however, this was ***confined*** to the ***immediate post-injury period*** and associated with **100% mortality**.

This data suggests that these high-grade vertebral artery injuries may require less intensive radiographic follow-up.



## Conclusions: Grade 1-2 BCI



*The majority of grade 1 and 2 BCIs remain stable or improved at final follow-up.*

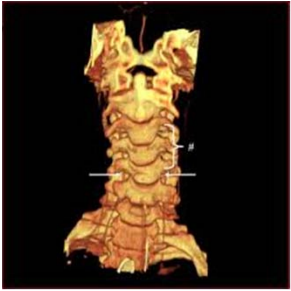
**Despite** a **14% rate of radiographic worsening** in the grade 1-2 BCI cohort, there were no adverse clinical outcomes associated with these radiographic changes.

*The stroke rate of 1% in this low-grade BCI cohort may be over-estimated.*

*.May be closer to 0.8%*

The **use of ASA** or other anti-platelet or anti-coagulant medications in these low-grade BCIs **did not correlate** with radiographic injury stability, **nor** with a decreased rate of cerebral infarction.

This data suggests that these grade 1 and 2 carotid artery injuries may require less intensive follow-up, as the **time and cost** allotted for this follow-up may not be entirely necessary.



## Conclusions: Grade 3-4 BCI



*The stroke rate of 7% for grade 3-4 BCI may be over-estimated.*

*May be closer to 3.5%*

Grade 3 and 4 BCIs carry **among the highest stroke risk of the blunt cerebrovascular injuries (BCVI).**

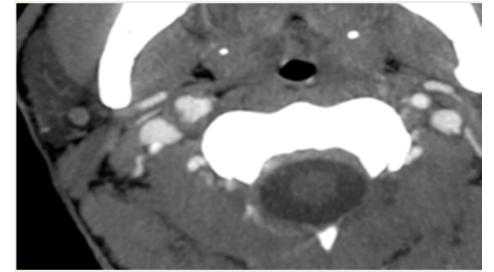
...and those infarctions occurred *upon or shortly after* hospital admission.

**Despite** a 40% recanalization rate in the **grade 4 BCI** group and an **89% rate of persistent pseudoaneurysm** in the **grade 3 BCIs** group, follow-up imaging showed progressive worsening without radiographic improvement in only a small portion of patients, and all of these findings independently ***did not*** correlate with adverse clinical outcome.





# Final Results BCVI



**328 patients** with **393 blunt vascular injuries** available for *close* follow-up.

.64.6% of patients were **male**, with average age of **36 years**; **MOI**: MVC (**63%**) > Fall (**18%**) > MCC (**8%**) > other injuries (ATV, MPC, assault, *etc.*)

–Average follow-up: **69 days**

–**80 patients excluded**: *47 pts LTF (followed for mean 9.7 admission days)*

•All received post-traumatic cranial imaging, no radiographic or symptomatic findings suggesting stroke, all discharged in stable, neurologically intact condition.

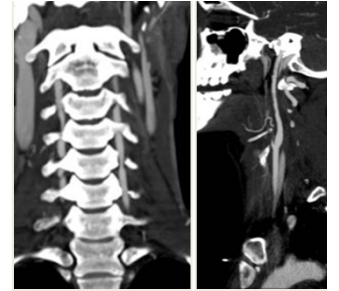
**.33 patients**: Deceased (29); Transferred (1); No imaging (3)

**Final radiographic results for BCVI:**

–**Stable: 42%; Improved: 18%; Resolved: 32%; Worsened: 8%**



# Final Results BCVI



## Treatments provided:

-**ASA alone: 73%**; ASA plus another medication (e.g. clopidogrel), or other: **9%**; No medication: **18%**; Endovascular intervention: **11%** of all cases.

**Stroke rate for all follow-up BVCI: 2.4% (8/328)**

***-If include LTF group: 2.1% (8/375)***

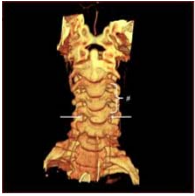
***-If omit the 2 cases of infarct likely unrelated to BCVI: 1.6% (6/375)***

**.Grade 4 BCI (1/5, 20%) > Grade 4 BVI (3/43, 7%) > Grade 3 BCI (3/44, 7%::3.5%) > Grade 1-2 BCI (1/100, 1%::0.8%) > Grade 1-2 BVI (2/120, 1.7%::0.7%) > Grade 3 BVI (0%).**

-All strokes were radiographically identified by average of **43 hours**.

***-Prolonged morbidity: 0.2 - 0.3% (1/375-328; 1 case in grade 1-2 BCI cohort).***

***-Mortality rate: 0.8 - 0.9% (3/375-328; 3 cases from grade 4 BVI cohort).***



# Final Conclusions BCVI



***BCVIs are stable, improved or resolved in the majority (92%) of cases.***

The use of **ASA** or other anti-platelet or anti-coagulant medications in the **low-grade BCVI cohorts** did **not correlate** with radiographic injury stability, ***nor*** with a decreased rate of cerebral infarction.

**Despite** a **2.6%** rate of radiographic worsening in low-grade BVI cases, a **4%** rate of radiographic worsening in the grade 3 BVI group, a **35% recanalization rate** in the grade 4 BVI group, a **14%** rate of radiographic worsening in the low-grade BCI cases, an **89% rate of persistent pseudoaneurysm** in the grade 3 BCIs group and a **40% recanalization rate** in the grade 4 BCI group...***there were no adverse clinical outcomes associated with these radiographic changes.***

***Low-grade BCVIs carry a lower stroke rate (average of 0.8%) compared to the high-grade cohorts (average of 5.3%), and these infarctions tended to occur upon or shortly after hospital admission.***

***The BCVI stroke rate of 2.4% is likely overestimated, and is probably closer to 1.6%.***

This data suggests that BCVIs may require less intensive follow-up, but further prospective studies are needed to make conclusive changes as it relates to management.

# 10-Year Retrospective Analysis of Clinical and Radiographic Outcomes Following Traumatic Carotid and Vertebral Artery Injuries from a Level 1 Trauma Center

*Thank You*

