Radiology Corner Case 27

Severe Epistaxis from an Intracranial Vascular Bleed from Grenade Injury

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Note: This is the full text version of the radiology corner question published in the August 2008 issue, with the abbreviated answer in the September 2008 issue.

This case demonstrates the importance of trajectory analysis of blast and/or ballistic penetrating head and neck injuries. In particular, this case focuses on an intracranial vascular injury generated by a hand grenade with the diagnosis assisted by trajectory mapping using MDCT (Multi-Detector CT) volumetrically acquired datasets. Further, this case shows the usefulness of reformatted images to analyze projectile wound trajectories and reviews complex anatomic planes for use in triage, treatment, and incident analysis in penetrating trauma.

Introduction

This 45 year old patient was involved in a hand grenade blast while conducting operations in Iraq. He was in a room when a grenade exploded on the ground to his left. The patient initially thought he sustained only minor injuries. He presented to the emergency room with severe unilateral epistaxis five days following his injury. On physical examination the patient had a normally healing 3-5mm diameter fragment entry wound on his anterior face (figure 1A). The neck scar (Figure 1B) was not initially considered as part of the same event. Entry wounds were to the left of midline, the first superficial to the left maxillary sinus and 2 cm lateral to the ala, and the second just left of midline at the base of the anterior neck.

Fig. 1 (A) Grenade fragment entrance scar over left maxillary sinus.

Fig. 1 (B) Grenade fragment scar in left anterior neck noted after CT findings of grenade fragment in right vallecula and trajectory analysis increasing the conspicuity of potential pathways for other fragments.

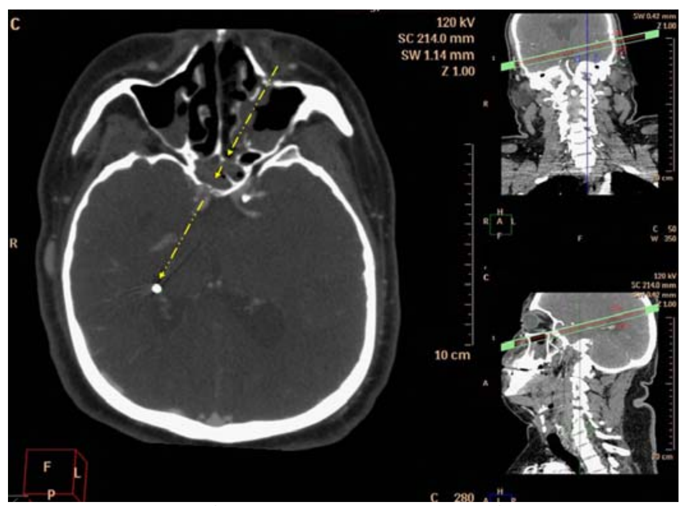

Fig. 2. Para-axial reformatted CT showing grenade fragment adjacent to the right lateral ventricle. The trajectory path is highlighted with the arrow. The complex plane orientation is shown on the corresponding true coronal and sagittal scout images to the right.

Summary of Imaging Findings

Non contrast CT of the brain with follow-up CTA of the carotids and Circle of Willis were performed. The even number system accounted for all fragments entering the patient and entrance wounds (in that the two fragments on CT correlate with the two entrances noted clinically, for a total of four)(1). An odd number total of entrances, exits, and fragments prompts the radiologist and ER physician to search for additional entry points, fragments, or exit points. Figure 2

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shows a fragment located adjacent to the atrium of the right lateral ventricle. On closer inspection and trajectory analysis of the fragment path to help determine further injury, the entrance was determined to match the clinical entrance over left maxillary sinus. The path was further determined to pass through the posterior maxillary sinus (with resultant fluid level and other soft tissue opacities consistent with blood), and the anterior and posterior sphenoid sinus.

Curvilinear planar reformation with vessel extraction showed a persistent narrowing of the cavernous segment of the internal carotid artery in proximity of the posterior sphenoid sinus wall fracture, with an intimal flap at the inferior aspect, consistent with dissection.

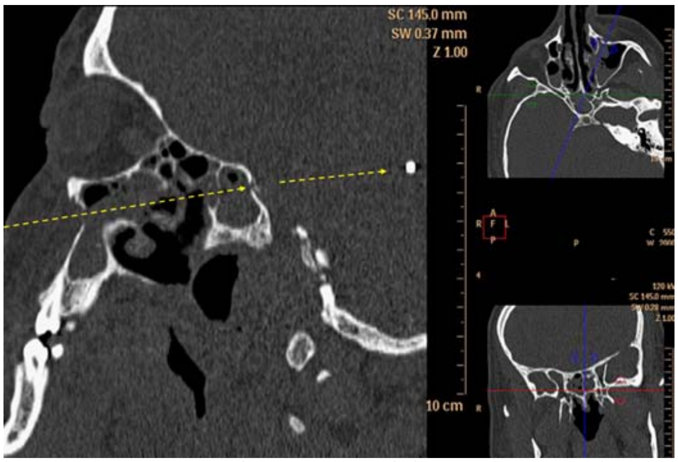

Fig. 3. Parasagittal reformatted CT of face demonstrating fragment trajectory through maxillary and sphenoid sinus anteriorly and posteriorly, with termination adjacent to the right lateral ventricle. Note the classic beveling of posterior sphenoid sinus, supporting the path from anterior to posterior.

Patient Discussion

The patient was hemodynamically stable and the epistaxis discontinued within about 30 minutes after admission. The patient was transferred to ICU in the forward deployed combat hospital, then further transferred in stable condition.

Diagnosis

Severe Epistaxis from an Intracranial Vascular Bleed from Grenade Injury

A small amount of active extravasation into the sphenoid sinus was noted on CTA (figure 4). This was presumed to be the cause of the severe epistaxis. A small pseudoaneurysm of the cavernous portion of the internal carotid artery was also noted. Para-axial and para-sagittal reformations demonstrated the grenade fragment trajectory entered the left maxillary sinus. This was discovered only after careful analysis of the tract and correlation with clinical findings. A second fragment (see figure 5) was located in the right pyriform sinus, which the patient denied swallowing. After examination of the volumetrically acquired CT data, the path of this fragment was found to be parallel to that of the intracranial fragment confirming the patient's account. See figure 6 for comparison of trajectories and the parallel nature. There was slight offset of the facial/ brain path towards the right, possibly indicating the patient's head was turned slightly to the right during the explosion. See figure 7 for artist's rendition of entrances, trajectories and complex planes.

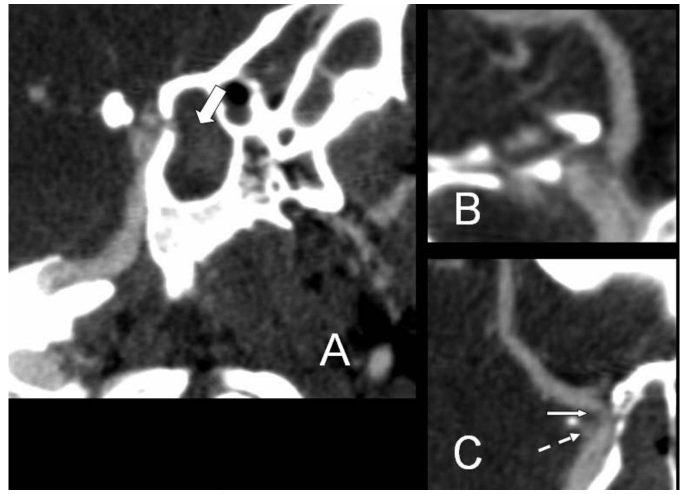

Fig. 4. Curvilinear reformations (B and C) centered around the cavernous segment of the internal carotid artery. On figure C, note the pseudoaneurysm (dotted arrow) and intimal flap (thin arrow). The para-sagittal (fig A) localizer shows a small amount of active bleeding through the perforating defect of the posterior aspect of the sphenoid sinus (wide arrow).

Discussion

Patients arriving at the ER with fragmentation injuries must be evaluated and re-triaged to CT or operating room carefully so that efficient use of surgical resources can be maintained. This is very important in the deployed setting since resources can be limited. For penetrating brain injuries, plain radiographs may be helpful, yet when CT is available, plain radiography is not recommended(2). Angiography, when available, is indicated in patients with penetrating brain injury when major vascular injury is suspected(3,4). If angiography is prohibitive, or not available, curvilinear multiplanar reformation of CTA may be used to visualize intracranial vessels. Multiplanar reformation (MPR) can be quite useful in determining the extent of injury as well as the next appropriate step in treatment for these patients(5).

The ability to accurately describe the trajectory and potentially involved anatomic structures to emergency physicians, trauma surgeons, and neurosurgeons is paramount. This cannot be overemphasized in the deployed setting where the radiologist assumes a key role in the re-triage of critically injured patients. In this particular case, radiological triage allows the patient to be efficiently moved to the most appropriate surgical subspecialty for evaluation. The images analyzed were obtained on a Phillips (The Netherlands) 16 Slice CT with the Phillips dedicated Phillips Brilliance Workstation.

MPR uses computerized imagery reformatting to define complex anatomical planes which result in unique combinations of the traditional anatomical planes(5). Such planes allow the tracing of the fragment in question from its entry into the body all the way along its path to its resting place. It is important to note that in head wounds caused by projectiles, destabilization of the projectile by bone may lead to greater injury(6). Correlation of final resting place, or exit location, with injured "real estate" along the path can be difficult but is of great importance. In penetrating brain injuries small areas traversed by projectiles may play a large role in their management. In this case there were several areas of interest, but most concerning was the internal carotid artery. A larger aneurysm or extravasation here could have devastating consequences if undiagnosed.

Fig. 5. Parasagittal reformatted CT of neck demonstrates a second grenade fragment in the right vallecula. Note wound path as linear diffuse opacity from left anterior neck (see arrow indicating path in figure 6).

Volumetric acquisition and MPR are also useful during incident analysis of firefights/ battles, sniper attacks, blast scenes, and at times fatalities. Because projectile tracts are related to the position of the patient at the time of injury, the examining radiologist along with a forensic radiologist (virtual autopsy) may use inter-planar images to assist in the forensic analysis of a scene(7,8). Further, projectile tracts can help demonstrate fragment scatter and help clarify injury patterns, two key components in a forensic scene reconstruction(9,10). Visualizing the path of projectiles will give insight into the orientation of the patient to an explosion or sniper(10). When a fragment passes through bone, the direction of entry may be determined on CT analysis based on characteristic beveling of the bone in the direction of travel(11). This is useful in determining both entry and exit wounds(11). Careful analysis of the path left by the projectile may shed light on the nature of its origin based upon correlation with ballistics(12). For example, a tumbling projectile will leave a greater defect on impact, and once in tissues a temporary cavity larger than expected, than if it were to travel without tumbling(6,12).

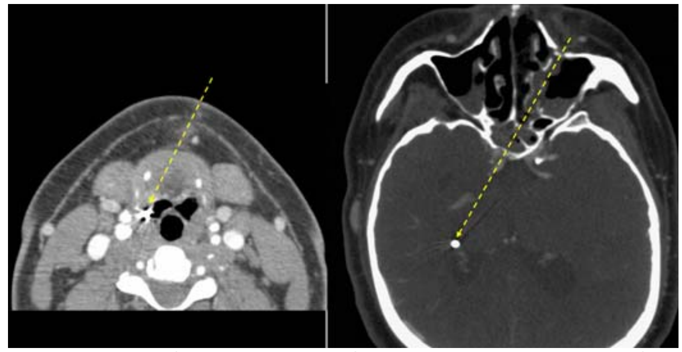

Fig. 6. Grenade fragments entered inferior to patient's head/neck and from left to right. Grenade was at ground level to left of patient during explosion and patient's head was facing forward, presumably slightly turned toward the right.

In addition, depth of penetration may be correlated with projectile mass and velocity at impact. Fragment penetration should allow an approximation of the patient's proximity to the explosion origin(9). Assembly of these factors allows investigators to generate a theory as to the origin of the fragment and weapon used to produce it. Because CT provides a permanent electronic record, images produced may be reformatted at a later time for the purpose of such analysis.

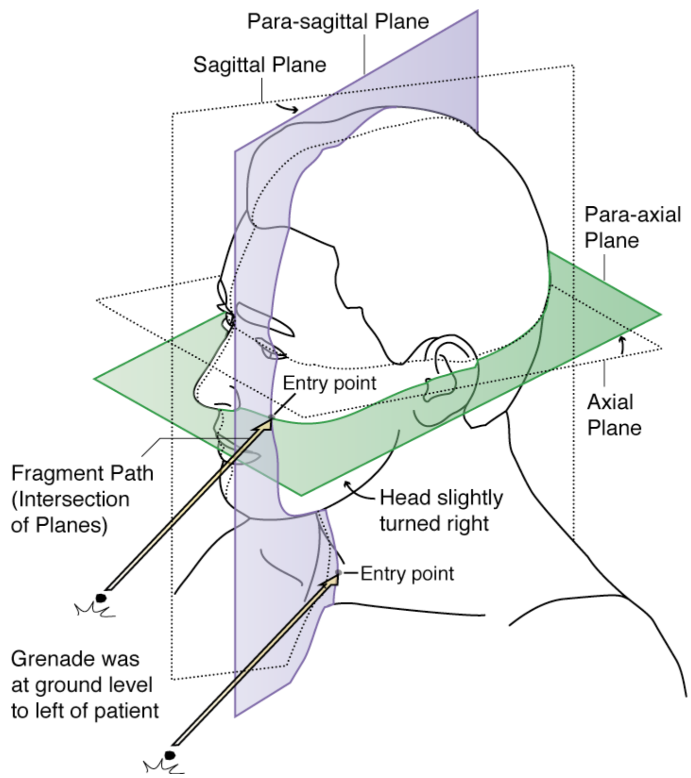

Fig. 7. Artist's rendition of para-sagittal and para-axial planes shown relative to mid-sagittal plane.

In this case both the para-axial and para-sagittal planes are exploited to give a complete picture of the desired paths (Figure 7). As described earlier, these planes are unique combinations of the standard anatomical planes. Para-sagittal and para-axial imagery are derived by rotation about the standard axis from parallel up to 45 degrees in either direction. Beyond the 45 degree point, the next intermediary plane is named(5).

Use of MPR and complex plane analysis in this case allowed for the appropriate re-triage and treatment for the patient. Finding the active intracranial vascular bleed and extravasation into the sphenoid sinus raised the re-triage level of this patient for increased attention. Determining the para-axial and para-sagittal plane of the first detected fragment allowed for increased conspicuity as to the etiology of the second fragment as the path may have otherwise gone undetected. Since the CT data is often not successfully transferred with the patient, reporting of the tilt, pitch, and axis of such complex planes may add to the medical record for long term follow-up of fragments unevaluated before reaching higher echelons of care. Utilization of this technique in similar incidents may be useful in the elucidation of a patient's disposition, and/or forensic analysis.

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Category 1 CME or CNE can be obtained on the MedPix™ digital teaching file on similar cases by opening the following link. Many Radiology Corner articles are also a MedPix™ Case of the Week where CME credits can be obtained.

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