

Radiology Corner

Case # 26 Lung laceration with active bleeding, contusion and hemothorax

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

The following case demonstrates the importance of emergent imaging in patients with thoracic gunshot wounds. The AP chest in our case highlights findings that correlate well with follow up CT Angiogram of the chest. A companion case is provided to illustrate wound dynamics in the lung with a variation of extent of intrathoracic bleeding. This case also exemplifies application of complex planes that are now commonplace with modern CT imaging capabilities described here as para-axial, para-coronal and para-sagittal reconstructions.

History

Our patient is a 31 year old active duty male deployed troop suffering a gunshot wound (GSW) to the left chest. This combat casualty was immediately med-evaced from field conditions to a combat hospital in Iraq. The patient was hemodynamically stable in the ER, with the following AP chest image obtained to evaluate involvement and estimate missile trajectory. This, combined with the clinical observation of single entrance wound to upper left chest anteriorly, demonstrated the bullet overlying the mediastinum, likely posterior.

Summary of Findings:

Figure 1 demonstrates the bullet overlying the mediastinum, likely posterior, based on isolated anterior entrance noted clinically and the associated wedge-shaped contusion and loculated blood. The blood is contained in resultant cavity from the missile path through the involved left lung (confirmed by CT). Blunting of the left costophrenic angle is noted, as well as overall haziness of left lung field peripherally, representing hemothorax (also confirmed by CT). It is believed that the position of the wedge of consolidation in the lung on the AP radiograph is slightly more inferior than one would expect due to positional variation between injury and treatment. In addition, there is decreased expansion of the left hemithorax representing overall volume loss on the left. Surgical staples are noted in the enlarged soft tissues of the left lateral chest wall.

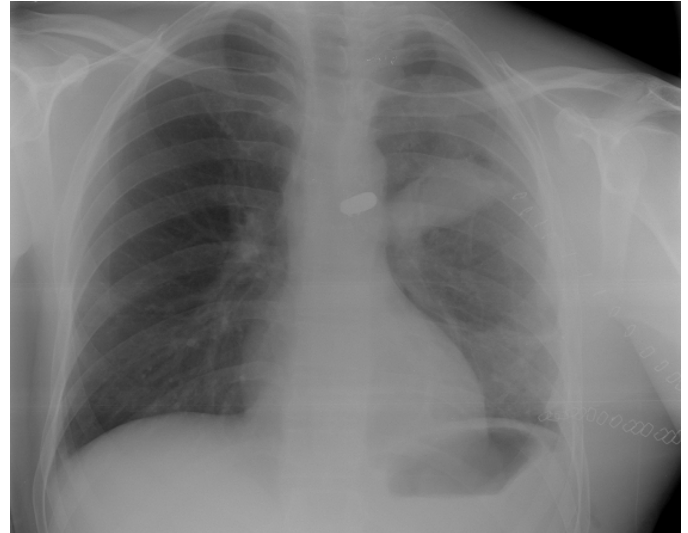


Fig. 1. The metallic bullet is overlying the left mediastinum. Note associated lung contusion represented by wedge-shaped opacity with apex towards bullet. Hazy opacity of left lung field with blunting of left costophrenic angle represents hemothorax.

Figure 2 confirms the lung contusion on the para-axial reformation aligned with the trajectory of the missile path. The Parenchymal tearing is evident by the obliquely oriented, sausage-shaped opacity representing bleeding into a resultant laceration (see companion case for example of cavity that is not filled with blood). The surrounding cloud-like high attenuation region represents contusion from ballistic effects (tumbling, shock wave) that follows a projectile, similar to the wake of a boat through water.

Diagnosis

Lung laceration with loculated blood in resultant cavity, active bleeding, contusion and hemothorax

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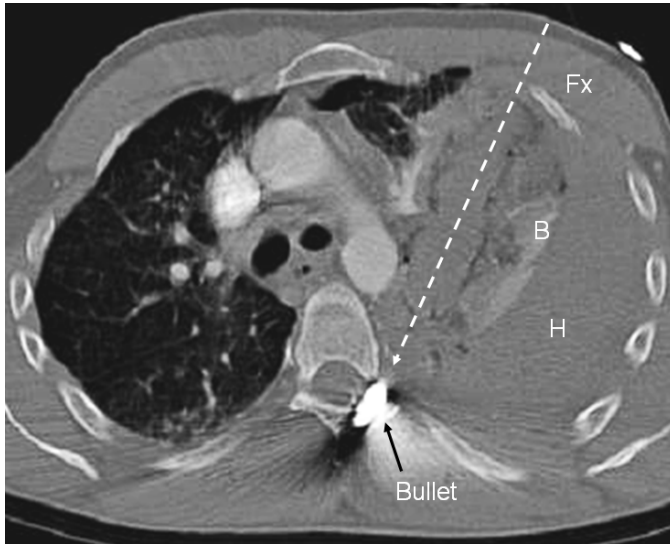


Fig. 2. The lung contusion seen on plain CXR is confirmed on the above para-axial CT reformatted through the missile path (dotted arrow). Note the sausage-shaped opacity obliquely oriented and pointing towards bullet (fluid opacity surrounding dotted arrow). The bullet lodged in the upper thoracic spine laterally. Note large hemothorax (H). There was sparing of major vessels, however, some small active bleeding (B) was noted by linear areas of increased attenuation areas seen here and on adjacent slices.

Figure 3 is a parasagittal reformation that also shows the sausage shaped opacity representing the blood filled cavity, in a superior to inferior and anterior to posterior trajectory path.



Fig. 3. The missile trajectory can be appreciated on this para-sagittal reformatted image showing anterior to posterior direction of GSW, as well as superior to inferior direction. Missile path is again depicted by the dotted arrow. Note surrounding filling in of resultant cavity from ballistic damage. The previously shown hemothorax is again appreciated posteriorly (dependent, H).

Patient discussion:

Imaging trauma patients in combat hospitals follows protocol guided by ATLS, ACLS and operating instructions of specific hospitals, not unlike CONUS based trauma centers. In deployed Air Force Theater Hospitals, trauma patients get a portable AP chest radiograph after the patient has been rolled to one side to check for spinal abnormalities, posterior lacerations from blast or ballistic injury and rectal tone. When the patient is turned back supine, the x-ray technologist slips the CXR plate behind the patient, with a new blanket exchanged for the often blood-soaked blanket or sheets. In hemodynamically stable thoracic GSW patients such as ours, an immediate CT Angiography of the chest is obtained to evaluate potential major vascular or cardiac involvement, spinal cord compromise, active bleeding, missile path, hemothorax or pneumothorax and lung involvement.

The resultant CXR demonstrated classic findings of lung contusion (with laceration and loculation found on CT), hemothorax and projectile. The follow-up CT validated the extensive hemothorax and blood-filled cavity in left lung. This imaging helped guide surgeons more definitively on this case, while maximizing resources for other casualties being diagnosed and treated simultaneously.

Companion Case

A companion GSW to the chest case is described at this point to illustrate some differences, similarities, and further use of complex plane descriptors in modern day imaging. This case is shown in figure 4 and demonstrates a lung laceration without the filling in of blood as in our case described earlier. Also note the surrounding consolidation representing contusion is similar. There is minimal hemothorax in this case, no evidence of active bleeding.



Fig. 4. A companion case is shown here to illustrate the use of complex planar reformats in a similar GSW to the chest. In this case there is no filling in of the resultant lung laceration (sausage-shaped lucency around dotted line depicting missile path). There is also less hemothorax, more subcutaneous emphysema in anterior left chest wall and fracture of left posterior rib. It is interesting to note that the left scapula is not fractured, even though it is along the trajectory path. This would indicate that the scapula was in a different position (like arm raised as opposed to at their side) during the gun shot.

Multi-Detector CT (MDCT) is a tool commonly used to determine the bullet trajectory or wound path through tissues.^{1,2} It is also the primary diagnostic tool.³ Trajectory is vital, but not the only factor that determines the damage done by a projectile. The permanent wound cavity is the damage done directly by the projectile along its trajectory. There is also a temporary wound cavity, caused by pressure waves created by and following the projectile as it passes through tissue, mentioned earlier. This temporary wound cavity is created by deformation of tissue as it is displaced by the pressure wave. Some tissue stretches easily and is less vulnerable to damage by this mechanism, such as muscle. Other, more friable tissue, as in solid organs like liver or spleen, are more vulnerable to damage. Blood vessels can also be torn by this deformation.^{1,3} In our initial Radiology Corner case, the cavity seen on CT resulted from the ballistic effects, without major vessel disruption, however, some active bleeding.

Multi Planar Reconstruction (MPR) and Complex Planes Discussion

Recent developments with MDCT imaging have provided an ability to reconstruct complex planes in better detail than ever before. The authors believe that the transformational technology advancement has surpassed our ability to adequately quantify these new orientations in medical reporting, academics and medical literature in general. In our literature search, we could not find accurate descriptions of the new displays that are now common, especially in penetrating trauma. See figure 5 for an artist's rendition of the complex planes added to the commonly known cardinal anatomic planes. See figures 6 and 7 for application of these complex plane descriptions in our case.

We further hypothesize that accurate and quantitative description will help in incident analysis of crime scenes and military firefights when dealing with multiple gunshot victims. Determining and describing trajectory angles using standard polar coordinates may help the study of individual incidents as well as from an epidemiologic perspective in recording gunshot and blast trajectories for years to come. Knowing the para-axial or otherwise complex planes of known fragments may help solve for unknown fragments by keeping the same para-axial orientation during interpretation. In addition, consistent reporting, standard nomenclature and possibly quantification should allow for more descriptive recording of GSW and blast fragments; especially since many of the original image datasets are often lost during transition of wounded warriors through the echelons of care. More research is needed in this specific area. A familiar use of such trajectory determination is the extensive investigation and analysis of President Kennedy's assassination in the 1960's.

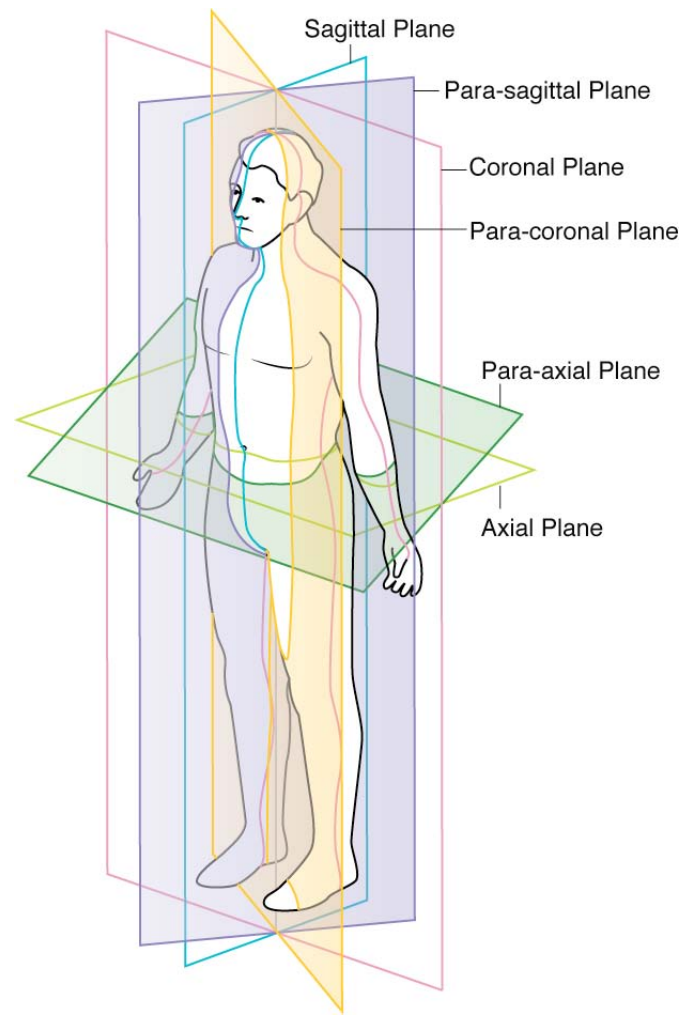


Fig. 5 Artists rendition of example complex planes possible with modern imaging. The complex planes and proposed nomenclature are defined here as intermediaries of the simple planes described above. Each of the planes here are 30 degrees off their parent planes as an example.

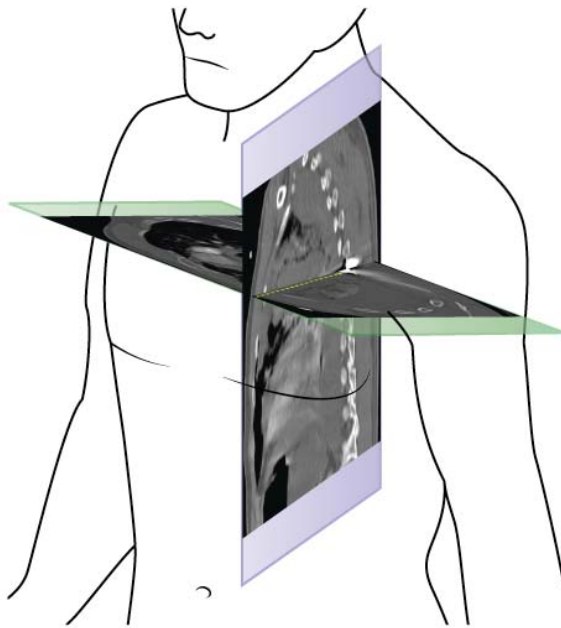


Fig 6. Anatomic superimposition of the tilted para-axial and parasagittal CT images with intersecting line to show bullet path on artist's anatomic model. This information can be helpful in recreating a sniper incident or battle scenario.

The authors presented two cases highlighting wound ballistics in the chest. The companion case demonstrated a resultant cavity from the missile that was not filled with blood as a comparison. The advantages of volumetric imaging and MPR in complex planes were demonstrated with these cases. An introduction to complex planes and proposed descriptive nomenclature was described. Now that imaging capabilities have matured and applied in the combat trauma setting, the authors believe that further research is needed on the application and quantification of complex planes.

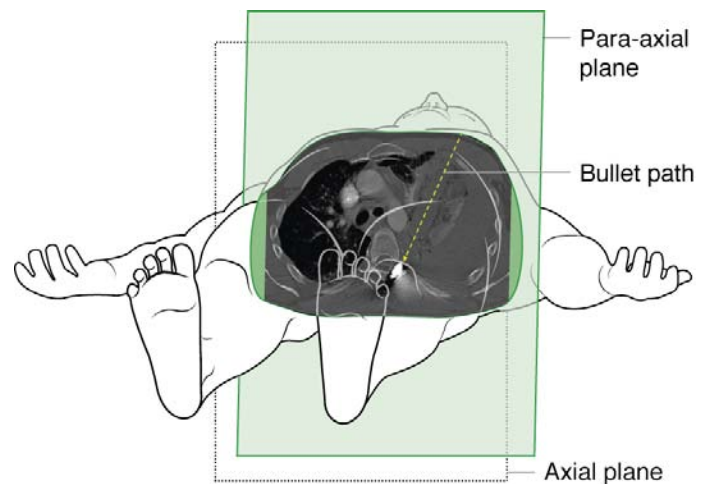


Fig 7. Superimposition of the para-axial slice showing the bullet trajectory within the anatomic model from feet-up perspective. These types of spatial orientations may help convey the trajectory to ER physicians, trauma surgeons and to those recreating the scene from an incident analysis perspective.

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Category 1 CME or CNE can be obtained on the MedPix™ digital teaching file on similar cases by following 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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