IMAGING OF PENETRATING TRAUMA
(STAB INJURIES, GUNSHOT WOUNDS, IMPALEMENT INJURIES)
- REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

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SUMMARY OF RECOMMENDATIONS
- an evidence-based consensus by International and Nordic clinical and radiological experts

ISOLATED PENETRATING HEAD INJURY

- **ALL PATIENTS**
  - non-contrast head CT (use scout to localize foreign objects)

- **SALVAGEABLE PATIENTS**
  - non-contrast head CT (use scout to localize foreign objects)
  - CTA from vertex to aortic arch (neck CTA) to detect vascular injuries
    - Facial vascular injuries are included
  - CTV in selected cases if sinus rupture is suspected (such as in penetrating posterior fossa injuries)
  - In case of GSW, consider additional
    - DSA if metal artifacts and CTA is inconclusive

Wound marks are not required

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ISOLATED PENETRATING NECK INJURY

WHICH PATIENT SHOULD GO TO RADIOLOGY

- Hemodynamically stable patients with suspected platysma injury, without “hard signs”**
  - *(active hemorrhage, expanding or pulsatile hematoma, bruit or thrill in the area of injury, shock unresponsive to initial fluid resuscitation, massive hemoptysis or hematemesis, and air bubbling through the injury site)

- Wound marks are recommended

WHAT RADIOLOGY EXAMS SHOULD BE PERFORMED

- CR (if CT is not available)
  - Localize foreign objects (bullets)

- CTA head+neck (from vertex to at least aortic arch)
  - CT scout to identify foreign objects
  - *Note*: CTA will reveal AV-fistulas as well

- CTA head+neck+thorax if “Zone I and II**” injuries, as 15-20% have chest injuries

If CT is inconclusive with regard to airway injury, consider laryngoscopy and/or bronchoscopy

In case of suspected cervical esophageal injury, endoscopy preferred to esophagography

In case of high suspicion and inconclusive endoscopy, consider esophagography (swallow study)

**Neck zones

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**Neck zones**

Zone 1

Zone 2

Zone 3

Zone 4

Zone 5

Zone 6

Zone 7

Zone 8

Zone 9

Zone 10
REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

PENETRATING TORSO (TRUNK) INJURY

EMERGENT SURGERY when needed – i.e. at the discretion of the surgeon in charge.

IMAGING IN ER/OR

Pre-CT imaging is not encouraged in stable patients

- Unstable patients
  - e-FAST and chest X-ray (+ pelvic X-ray in GSW)
    - Cave: Large hemotorax may conceal hemopericardium
  - Wound marking recommended (Arrow, paperclip, Vitamin E capsule...)

WHICH RADIOLOGICAL EXAMS SHOULD BE PERFORMED IN STABLE PATIENTS
(to help to decide to operate or not, and to guide the surgeon and/or interventionist)

1. CT scouts: localize foreign bodies in GSW to define the optimal scan length
2. CT chest-abdomen with i.v. contrast, especially if the entry wound is below intermammary line in stab wounds and almost always with GSW.
   a. Consider triple contrast CT. (Level II Evidence, see Appendix for details).
   b. Late arterial (to visualize arterial injuries) to lesser trochanters + venous phase abdomen.
   c. Add late phase (5-10 min delay) if kidney and ureter are in injury trajectory.
      Radiologist’s supervision required
3. CT cystogram should be performed in urinary bladder injuries
4. Wound marking strongly recommended (Arrow, paperclip, Vitamin capsule...)

CO₂-DSA can be used in unequivocal cases with suspected vascular injuries
Peroperative angiogram is not discussed here
Angioembolization is part of management and not discussed here

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PENETRATING EXTREMITY INJURY

- Exsanguinating or acutely ischemic and site of injury is known -> no vascular imaging
- CTA is the diagnostic study of choice when vascular imaging is required (Level 1 evidence)
- This applies, however, imaging outside OR. In OR, imaging is conventional angiography
- Wound marking is recommended.
MASS CASUALTIES – major incidents (MI)

PREPARATION

DISASTER PLAN SHOULD BE IN PLACE AND COORDINATED

- Radiology is an integral part of the response to major incidents
- Develop strategies to maintain effective communication (vertically and horizontally)
- Maintain CT capability and capacity during the reception phase of a MI
- Traumatic brain injury management is especially dependent on CT

PATIENT FLOW PLANNING

- Identification of patients
- Routine for identifying unknown patients
- Identify and eliminate bottlenecks
- Removal of patients from radiology department after scans

IMAGING

ROLE OF FAST/E-FAST

- Triage for CT in the initial phase

WHAT CT PROTOCOLS TO USE

- Whole body trauma protocol (WBCTT) available on all scanners, techs should be trained
- Ideally one standardized protocol for all hospitals for maximum efficiency
- Consider WBCT in ALL patients requiring CT in mass casualty events (especially blast events), to avoid rescans

IMAGE, READING AND REPORTING FLOW

- Basic imaging data to PACS
- Reading directly at CT or workstation
- Quick, concise documentation, standardized reporting*
- Consider backup paper-based system
- Life-threatening findings must be reported immediately

RADIOLOGY PLAYS A SIGNIFICANT PART IN MULTIDISCIPLINARY ASSESSMENT; WHICH SHOULD BE PLANNED FOR IN TERMS OF LOAD MANAGEMENT

* Standardized report example: http://www.nordictraumarad.com/Homepage/Download-File/f/287341/h/7ef5cf88d5ac5b8adb4a5ba2ea9d9bc8/Poster

End of consensus recommendation summary
Background/Presentation

Nordic forum for trauma and emergency radiology (NORDTER) staged this meeting as its third consensus conference. We held this multidisciplinary consensus meeting to review the literature and to scrutinize surgical and radiological routines. We invited international and Nordic expertise for guidance through the evidence in the literature; and summoned Nordic representatives for surgery, vascular surgery and trauma & interventional radiology to create evidence-based recommendations for the Nordic trauma scene.

As in our earlier consensus conferences; expert speakers presented the evidence/literature status for radiology/intervention and surgery/vascular surgery; followed by a consensus discussion. The group discussions followed an informal format with the chairperson directing discussion and delegating tasks. Although our group was encouraged to attempt to reach consensus, members were also encouraged to include alternative views.

The references after each topic were provided by the speakers. The number of references were kept to minimum, and only the most pertinent were included.


Expert speakers

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TRAUMA RADIOGRAPHERS
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The report and recommendations structure

a. Isolated penetrating head injury
b. Isolated penetrating neck injury
c. Penetrating torso (trunk) injury
d. Penetrating extremity injury
e. Mass casualties

Each part follows the same structure
I  Consensus summary
II  Action cards
III  Reference documents

The second part “Action Cards” (-structured information flow cards) presents the most important information in a structure geared to be used in the critical situation, possible to print and have at hand. The action cards answer the following questions: Who needs the information? What questions needs to be answered?


ISOLATED PENETRATING HEAD INJURY

ISOLATED PENETRATING HEAD INJURY

CONSENSUS SUMMARY:

- ALL PATIENTS
  - non-contrast head CT (use scout to localize foreign objects)
- SALVAGEABLE PATIENTS
  - non-contrast head CT (use scout to localize foreign objects)
  - CTA from vertex to aortic arch (neck CTA) to detect vascular injuries
    - Facial vascular injuries are included
  - CTV in selected cases if sinus rupture is suspected (such as in penetrating posterior fossa injuries)
- In case of GSW, consider additional
  - DSA if metal artifacts and CTA is inconclusive

Wound marks are not required.

ACTION CARD:

Who needs the information? What question(s) to be answered?

Surgeon – what radiological exam to order
- All patients - Non-contrast head CT –
- Salvageable patients – non-contrast head CT (use scout to localize foreign objects) – CTA vertex to aortic arch; – CTV if sinus injury is suspected
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Radiographer -What exam? What to prepare?
- Non-contrast CT of the Head; include whole face
- CTA – head & neck to aortic arch
  – CTV if sinus injury is suspected
- prepare contrast for all patients

Radiologist – What exam?
- ALL: Non-contrast CT of the Head; include whole face
FOR SALVAGABLE PATIENTS
- non-contrast head CT (use scout to localize foreign objects)
- CTA – head & neck to aortic arch -
  – CTV if sinus injury is suspected
- (GSW - DSA if metal artifacts/inconclusive CTA)

Diagnostic focus?
- (use scout to localize foreign objects)
- Brain injury,
- vascular injuries head & neck;
- facial injuries incl vascular

REFERENCES


ISOLATED PENETRATING NECK INJURY
WHICH PATIENT SHOULD GO TO RADIOLOGY

- Hemodynamically stable patients with suspected platysma injury, without “hard signs” *
  - *(active hemorrhage, expanding or pulsatile hematoma, bruit or thrill in the area of injury, shock unresponsive to initial fluid resuscitation, massive hemothysis or hematemesis, and air bubbling through the injury site)

- Wound marks are recommended

WHAT RADIOLOGY EXAMS SHOULD BE PERFORMED

- CR (if CT is not available)
  - Localize foreign objects (bullets)
- CTA head+neck (from vertex to at least aortic arch)
  - CT scout to identify foreign objects
  - Note: CTA will reveal AV-fistulas as well
- CTA head+neck+thorax if “Zone I and II**” injuries, as 15-20% have chest injuries

If CT is inconclusive with regard to airway injury, consider laryngoscopy and/or bronchoscopy

In case of suspected cervical esophageal injury, endoscopy preferred to esophagography

In case of high suspicion and inconclusive endoscopy, consider esophagography (swallow study)

**Neck zones

ACTION CARD:

Who needs the information? What question(s) to be answered?

Surgeon – Which patient to image?
- Hemodynamically stable patients with suspected or obvious platysma violation without “hard signs” – see below*

What radiological exam to order?
- CTA – head & neck → aortic arch & possibly thorax (Zone I + II) *
  - [If CT is not possible – consider radiographs to localize foreign object (bullets)]
- Wound marks are recommended (vitamin E capsules)

If inconclusive CT
- in regard to airway injury, consider laryngoscopy and/or bronchoscopy
- if suspected cervical esophageal injury, endoscopy preferred to esophagography
- In case of high suspicion & inconclusive endoscopy, consider esophagography (swallow study)
**Hard signs:** active hemorrhage, expanding or pulsatile hematoma, bruit or thrill in the area of injury, shock unresponsive to initial fluid resuscitation, massive hemoptysis or hematemesis, and air bubbling through the injury site

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**Radiographer - what to prepare?**
- CTA – head & neck → aortic arch & add thorax on request
- prepare contrast for all patients
- ask for wound marks

**Radiologist - what exam?**
- CTA head & neck to aortic arch – consider including whole thorax (zone I+II injuries)

**What diagnostic focus?**
- look for wound marks
- vascular injuries – ongoing bleeds, AV- fistulas
- lung mediastinal injuries
- airway injury?
- esophageal injury?
- look for foreign bodies (scout view!)

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**REFERENCES**


REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

PENETRATING TORSO (TRUNK) INJURY

PENETRATING TORSO (TRUNK) INJURY

EMERGENT SURGERY when needed – i.e. at the discretion of the surgeon in charge.

IMAGING IN ER/OR

Pre-CT imaging is not encouraged in stable patients

- Unstable patients
  - e-FAST and chest X-ray (+ pelvic X-ray in GSW)
    - Cave: Large hemothorax may conceal hemopericardium
  - Wound marking recommended (Arrow, paperclip, Vitamin E capsule)

WHICH RADIOLOGICAL EXAMS SHOULD BE PERFORMED IN STABLE PATIENTS
(to help to decide to operate or not, and to guide the surgeon and/or interventionist)

1. CT scouts: localize foreign bodies in GSW to define the optimal scan length
2. CT chest-abdomen with i.v. contrast, especially if the entry wound is below intermammary line in stab wounds and almost always with GSW.
   a. Consider triple contrast CT. (Level II Evidence, see Appendix for details).
   b. Late arterial (to visualize arterial injuries) to lesser trochanters + venous phase abdomen.
   c. Add late phase (5-10 min delay) if kidney and ureter are in injury trajectory.
      Radiologist’s supervision required
3. CT cystogram should be performed in urinary bladder injuries
4. Wound marking strongly recommended (Arrow, paperclip, Vitamin capsule…)

CO₂ DSA can be used in unequivocal cases with suspected vascular injuries
Peroperative angiogram is not discussed here
Angioembolization is part of management and not discussed here

ACTION CARD:

IMAGING IN ER/UNSTABLE PATIENT

Who needs the information? What question(s) to be answered?

  Surgeon – when & what radiological exam to order
  - Emergency surgery if needed
  - Unstable patients – e-FAST & chest X-ray & pelvic X-ray in GSW
  - Stable patients – Pre-CT imaging is NOT encouraged

  Radiographer – what exam? what to prepare?
  ER – chest/pelvic X-ray- (portable) x-ray machine
  - wound markings – paper clip/E-vitamin capsule
  - (e-FAST – bring ultrasound machine)
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Radiologist – what exam? What diagnostic focus?
- (e-FAST)
- chest X-ray; foreign bodies/wound markings
  beware – box of death – large hemothorax may conceal hemopericardium

IMAGING IN THE STABLE PATIENT
(to help to decide to operate or not, and to guide the surgeon and/or interventionist)

Who needs the information? What question(s) to be answered?

Surgeon - Contraindications to CT (see also full text document)
Absolute:
  Hemodynamic instability - Emergent laparotomy or thoracotomy is needed
Relative:
  Pneumoperitoneum on radiograph
  Peritonitis
  Hematuria: However, many renal injuries that can be managed nonoperatively may
  still present with hematuria. CT is often used for grading penetrating renal injuries
  Hematochezia: Usually indicative of hollow visceral injury requiring laparotomy
  Hematemesis

Surgeon –when CT:
- request CT thorax & abdomen - dual phase
  (- if agreed on locally, use triple contrast CT in dual phase)
- Wound marking strongly recommended, paper clip/E-vitamin capsule*

Radiographer – what exam? what to prepare?
- Use CT scouts to localize foreign bodies in GSW to define the optimal scan field
- CT chest-abdomen - late arterial (to visualize arterial injuries) to lesser trochanters +
  venous phase abdomen.
- Consider triple contrast – i.e. addition of oral + rectal contrast

- Contrast recommendations from Karolinska University Hospital, Stockholm:
  --- Oral:    50 ml iohexol (Omnipaque) 140 mg I / ml in 450 ml water;
  --- Rectal:  150 ml iohexol (Omnipaque) 140 mg I / ml in 1350 ml water
- late phase? – if urological injuries!
- if CT cystography: 25 ml Omnipaque 240 mg I / ml in 225 ml NaCl 9 mg/ml

Radiologist – what exam?
- CT chest-abdomen - late arterial (to visualize arterial injuries) to lesser trochanters +
  venous phase upper/whole abdomen.
- Consider triple contrast CT. (Level II Evidence). (if agreed on locally)
- Add late phase (5-10 min delay) if kidney and ureter are in injury trajectory.
- CT cystogram should be performed in urinary bladder injuries
- check Wound marking strongly recommended, paper clip/E-vitamin capsule etc.*
(- Use CT scouts to localize foreign bodies in GSW)

**What diagnostic focus?**

**Tangential or superficial wounds**: Exclusion of peritoneal or pleural penetration

**Thoracoabdominal wounds/anterior abdominal wounds**: For gastric, small bowel, or colonic injury, high-grade solid organ injury, pancreaticobiliary injury, major vascular injury, and diaphragmatic injury

**Transpelvic gunshot wounds**: For rectal or bladder injury, and intra- vs. extraperitoneal involvement; evaluate for major vascular injury;

**Back and flank wounds**: For retroperitoneal injury potentially involving colon, kidneys, ureters or major vessels

**Precordial, parasternal, periclavicular and transmediastinal wounds**: For cardiac injuries, closed aortic or great vessel injuries, and aerodigestive tract injuries

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**REFERENCES**


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REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

PENETRATING EXTREMITY INJURY

- Exsanguinating or acutely ischemic and site of injury is known -> no vascular imaging
- CTA is the diagnostic study of choice when vascular imaging is required (Level 1 evidence)
- This applies, however, imaging outside OR. In OR, imaging is conventional angiography
- Wound marking is recommended.

ACTION CARD:

Who needs the information? What question(s) to be answered?

**Surgeon — when & what radiological exam to order**
NO IMAGING needed when exsanguinating or acutely ischemic and site of injury is known.
CTA of the injured extremity – method of choice - Wound marking is recommended
In OR – conventional angiography

**Radiographer — what exam? what to prepare?**
CTA – prepare adding venous series over same field of examination

**Radiologist — what exam?**
CTA – consider adding venous series

What diagnostic focus?
Bleeding
Pseudoaneurysm
AV-fistula

REFERENCES


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MASS CASUALTIES – major incidents (MI)

PREPARATION

DISASTER PLAN SHOULD BE IN PLACE AND COORDINATED

- Radiology is an integral part of the response to major incidents
- Develop strategies to maintain effective communication (vertically and horizontally)
- Maintain CT capability and capacity during the reception phase of a MI
- Traumatic brain injury management is especially dependent on CT

PATIENT FLOW PLANNING

- Identification of patients
- Routine for identifying unknown patients
- Identify and eliminate bottlenecks
- Removal of patients from radiology department after scans

IMAGING

ROLE OF FAST/e-FAST

- Triage for CT in the initial phase

WHAT CT PROTOCOLS TO USE

- Whole body trauma protocol (WBCT) available on all scanners, techs should be trained
- Ideally one standardized protocol for all hospitals for maximum efficiency
- Consider WBCT in ALL patients requiring CT in mass casualty events (especially blast events), to avoid rescans

IMAGE, READING AND REPORTING FLOW

- Basic imaging data to PACS
- Reading directly at CT or workstation
- Quick, concise documentation, standardized reporting*
- Consider backup paper-based system
- Life-threatening findings must be reported immediately

RADIOLOGY PLAYS A SIGNIFICANT PART IN MULTIDISCIPLINARY ASSESSMENT; WHICH SHOULD BE PLANNED FOR IN TERMS OF LOAD MANAGEMENT

* Standardized report example: http://www.nordictraumarad.com/Homepage/Download-File/f/287341/h/7ef5cf88d5ac5b8ad4a5ba2ea9ddbc8/Poster
REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

ACTION CARD:

SURGEON
-when & what radiological exam to order

e-FAST – consider using e-FAST to triage for CT in the initial phase

Trauma-CT – consider including whole body scan for every patient to avoid rescanning
- (retransporting the patient to the CT suite during a major incident causes confusion)

RADIOGRAPHER
what exam? what to prepare?

Ideally one standardized CT-protocol for all for maximum efficiency

Consider WBCT in all patients requiring CT in mass casualty events
(especially blast events) to avoid rescans

RADIOLOGIST
what exam? What diagnostic focus?

e-FAST – consider using to triage for CT in the initial phase

Trauma-protocol available on all scanners.

Ideally one standardized protocol for all for maximum efficiency

Consider WBCT in all patients requiring CT in mass casualty events
(especially blast events) to avoid rescans

Basic imaging data to PACS, reading directly from modality console/workstation
Quick, concise documentation, standardized reporting - based on local practice
(consider backup paper-based system)
Life-threatening findings must be reported immediately

REFERENCES


REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017


ADDENDUM

- abbreviations
  - BCVI – blunt cerebrovascular injuries
  - CTA – CT angiogram
  - CTV – CT venogram
  - DSA – digital subtraction angiography
  - ER – emergency room
  - OR – operating room
  - e-FAST – Extended FAST (incl. exam for pneumothorax)
  - FAST – focused assessment with sonography for trauma
  - GSW – gunshot wound
  - Triple contrast CT – with oral, rectal and intravenous contrast media
  - WBCT – whole body CT
  - MI major incident–

- images – body areas
**Triple contrast CT** with the use of oral, rectal and intravenous contrast is recommended by US centers in order to optimize diagnosis of hollow viscus injuries. In blunt trauma free extraluminal air indicates visceral injury. In penetrating injury free air only indicates peritoneal violation. Thus, the use of oral/rectal contrast is more indicated in penetrating trauma, compared to blunt trauma CT. There is a fair amount of support in the literature for the use of triple contrast but no decisive evidence.

If triple contrast is to be used in the Scandinavian trauma scene, it is necessary to have a consensus agreement in the local hospital and to train the procedure, in order not to lose time in critical cases.

**Wound markings** are recommended with paper clips or Vitamin E capsules. Paper clips do not give significant artifacts in new CT scanners. Vitamin E capsules contain fat and give no artifacts at all.

**Contrast recommendations from Karolinska University Hospital, Stockholm:**
- Oral: 50 ml Iohexol (Omnipaque) 140 mg I / ml in 450 ml water;
- Rectal: 150 ml Iohexol (Omnipaque) 140 mg I / ml in 1350 ml water

In urinary bladder – CT cystography: 25 ml Omnipaque 240 mg I / ml in 225 ml NaCl 9 mg/ml.

**Reference for Triple contrast CT**


**INDICATIONS (from this reference article)**

1. **Tangential or superficial wounds:** Exclusion of peritoneal or pleural penetration.
2. **Thoracoabdominal wounds/anterior abdominal wounds:** For gastric-, small bowel, or colonic injury, high-grade solid organ injury, pancreaticobiliary injury, major vascular injury, and diaphragmatic injury
3. **Transpelvic gunshot wounds:** For rectal or bladder injury, and intra- versus extraperitoneal involvement; evaluate for major vascular injury; performed for surgical planning or to evaluate potential candidates for nonoperative management
4. **Back and flank wounds:** For retroperitoneal injury potentially involving colon, kidneys, ureters or major vessels
5. **Precordial, parasternal, periclavicular and transmediastinal wounds:** For cardiac injuries, closed aortic or great vessel injuries, and aerodigestive tract injuries
6. **Other:**
   a. For wounds not amenable to local wound exploration (ie, gunshot wounds, obese or muscular patients, back and flank injuries, wounds above costal margin, long obliquely oriented wounds)
   b. For severe distracting pain, neurologic injury, or intoxication, which may confound physical examination;
   c. For patients with neurologic or extremity injuries which require surgical intervention and cannot be closely monitored
CONTRAINDICATIONS (from this reference article)

Absolute:

- Hemodynamic instability not responsive or transiently responsive to fluid resuscitation (sometimes defined as systolic blood pressure <90 mmHg after 2 liters of intravenous fluid).
  - CT would delay life-saving care like emergent laparotomy or thoracotomy

Relative:

1. Pneumoperitoneum on radiograph: Air may result from perforated hollow viscera but can also be introduced into the abdominal cavity through wound track or from pneumothorax migrating through a diaphragmatic defect
2. Peritonitis: Subjective sign. May be masked or mimicked by severe pain. Classically from hollow visceral perforation but can sometimes result from solid organ injuries
3. Hematuria: May indicate surgical renal injury or ureteral injury. However, many renal injuries that can be managed nonoperatively may still present with hematuria. CT is often used for grading penetrating renal injuries
4. Hematochezia: Usually indicative of hollow visceral injury requiring laparotomy; however, hematochezia may result from extraperitoneal rectal injury, which can be treated laparoscopically in select cases. Preoperative CT can often be used to distinguish between extra- and intraperitoneal rectal injury
5. Hematemesis: If the patient is hemodynamically stable, CT may occasionally be used to determine injuries before surgical intervention
**ACTION CARD – SURGEON**

**MASS CASUALTIES – major incidents (MI)**

*When & what radiological exam to order*
- E-FAST – consider using e-FAST to triage for CT in the initial phase
- Trauma-CT – consider including whole body scan for every patient to avoid rescanning
  - (retransporting the patient to the CT suite during a major incident causes confusion)

**ISOLATED PENETRATING HEAD INJURY**

*What radiological exam to order*
- All patients – Non-contrast head CT –
- Salvageable patients – Non-contrast head CT and CTA vertex to aortic arch – CTV if sinus injury is suspected

**ISOLATED PENETRATING NECK INJURY**

*Which patient to image?*
- Hemodynamically stable patients with suspected or obvious platysma violation without “hard signs” – see below*

*What radiological exam to order?*
- CTA – head & neck → aortic arch & *possibly thorax* (Zone I + II) *
  -- [If CT is not possible – consider radiographs to localize foreign object (bullets)]
- Wound marks are recommended (vitamin E capsules)

*If inconclusive CT*
- in regard to *airway injury*, consider laryngoscopy and/or bronchoscopy
- if suspected cervical *esophageal injury*, endoscopy preferred to esophagography
- In case of *high suspicion & inconclusive endoscopy*, consider esophagography (swallow study)

*Hard signs*: active hemorrhage, expanding or pulsatile hematoma, bruit or thrill in the area of injury, shock unresponsive to initial fluid resuscitation, massive hemoptysis or hematemesis, and air bubbling through the injury site
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PENETRATING TORSO (TRUNK) INJURY

IMAGING IN ER/UNSTABLE PATIENT

When & what radiological exam to order

Emergency surgery if needed
- Unstable patients – e-FAST & chest X-ray & pelvic X-ray in GSW
- Stable patients – Pre-CT imaging is NOT encouraged

IMAGING IN THE STABLE PATIENT

(to help to decide to operate or not, and to guide the surgeon and/or interventionist)
- Contraindications to CT (see also full text document)
  
  ** Absolute:**
  - Hemodynamic instability - Emergent laparotomy or thoracotomy is needed
  
  ** Relative:**
  - Pneumoperitoneum on radiograph
  - Peritonitis
  - Hematuria: However, many renal injuries that can be managed nonoperatively may still present with hematuria. CT is often used for grading penetrating renal injuries
  - Hematochezia: Usually indicative of hollow visceral injury requiring laparotomy
  - Hematemesis

When CT:
- request CT thorax & abdomen - dual phase
  (- if agreed on locally, use triple contrast CT in dual phase)
- Wound marking strongly recommended, paper clip/E-vitamin capsule*

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PENETRATING EXTREMITY INJURY

Who needs the information? What question(s) to be answered?

Surgeon – when & what radiological exam to order

- NO IMAGING needed when exsanguinating or acutely ischemic and site of injury is known.
- CTA of the injured extremity – method of choice - Wound marking is recommended
- In OR – conventional angiography
REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

ACTION CARD RADIOGRAPHER

ISOLATED PENETRATING HEAD INJURY

Radiographer - What exam? What to prepare?
- Non-contrast CT of the Head; include whole face
- CTA – head & neck to aortic arch
  (– CTV if sinus injury is suspected)
- prepare contrast for all patients

ISOLATED PENETRATING NECK INJURY

Radiographer - what to prepare?
- CTA – head & neck → aortic arch & add thorax on request
- prepare contrast for all patients
- ask for wound marks

PENETRATING TORSO (TRUNK) INJURY

IMAGING IN ER/UNSTABLE PATIENT

Radiographer – what exam? what to prepare?
ER – chest/pelvic X-ray- (portable) x-ray machine
- wound markings – paper clip
- (e-FAST – bring ultrasound machine)

IMAGING IN THE STABLE PATIENT

Radiographer – what exam? what to prepare?
- Use CT scouts to localize foreign bodies in GSW to define the optimal scan field
- CT chest-abdomen - late arterial (to visualize arterial injuries) to lesser trochanters+ venous phase abdomen.
- Consider triple contrast – ie addition of oral + rectal contrast

- Contrast recommendations from Karolinska University Hospital, Stockholm:
  - Oral: 50 ml iohexol (Omnipaque) 140 mg I / ml in 450 ml water;
  - Rectal: 150 ml iohexol (Omnipaque) 140 mg I / ml in 1350 ml water
- late phase? – if urological injuries!
- if CT cystography: 25 ml Omnipaque 240 mg I / ml in 225 ml NaCl 9 mg/ml

PENETRATING EXTREMITY INJURY

Radiographer – what exam? what to prepare?
CTA – prepare adding venous series over same field of examination
MASS CASUALTIES – major incidents (MI)

Radiographer – what exam? what to prepare?
Ideally one standardized CT-protocol for all for maximum efficiency

Consider WBCT in all patients requiring CT in mass casualty events (especially blast events) to avoid rescans
ACTION CARD – RADIOLOGIST

ISOLATED PENETRATING HEAD INJURY

Radiologist – What exam?
- ALL: Non-contrast CT of the Head; include whole face
  FOR SALVAGABLE PATIENTS
  - Non-contrast head CT
  - CTA – head & neck to aortic arch -
    - CTV if sinus injury is suspected
  - (GSW - DSA if metal artifacts/inconclusive CTA)

Diagnostic focus?
- (use scout to localize foreign objects)
- Brain injury,
- vascular injuries head & neck;
- facial injuries incl vascular

ISOLATED PENETRATING NECK INJURY

Radiologist - what exam?
- CTA head & neck to aortic arch – consider including whole thorax (zone I+II injuries)

What diagnostic focus?
- look for wound marks
- vascular injuries – ongoing bleeds, AV- fistulas
- lung/mediastinal injuries
- airway injury?
- esophageal injury?
- look for foreign bodies (scout view!)

PENETRATING TORSO (TRUNK) INJURY

IMAGING IN ER/UNSTABLE PATIENT
Radiologist – what exam?  What diagnostic focus?
- (e-FAST)
- chest X-ray; foreign bodies/wound markings
  beware – box of death – large hemothorax may conceal hemopericardium

IMAGING IN THE STABLE PATIENT
Radiologist – what exam?
- CT chest-abdomen - late arterial (to visualize arterial injuries) to lesser trochanters+
  venous phase upper/whole abdomen.
- Consider triple contrast CT. (Level II Evidence). (if agreed on locally)
- Add late phase (5-10 min delay) if kidney and ureter are in injury trajectory.
- CT cystogram should be performed in urinary bladder injuries
- check Wound marking strongly recommended, paper clip/E-vitamin capsule etc.*
REPORT FROM NORDTER CONSENSUS MEETING, SIGTUNA OCT 18-19, 2017

(- Use CT scouts to localize foreign bodies in GSW)

What diagnostic focus?
Tangential or superficial wounds: Exclusion of peritoneal or pleural penetration
Thoracoabdominal wounds/anterior abdominal wounds: For gastric, small bowel, or colonic injury, high-grade solid organ injury, pancreaticobiliary injury, major vascular injury, and diaphragmatic injury
Transpelvic gunshot wounds: For rectal or bladder injury, and intra- versus extraperitoneal involvement; evaluate for major vascular injury;
Back and flank wounds: For retroperitoneal injury potentially involving colon, kidneys, ureters or major vessels
Precordial, parasternal, periclavicular and transmediastinal wounds: For cardiac injuries, closed aortic or great vessel injuries, and aerodigestive tract injuries

PENETRATING EXTREMITY INJURY

Radiologist – what exam?
CTA – consider adding venous series

What diagnostic focus?
Bleeding
Pseudoaneurysm
AV-fistula

MASS CASUALTIES – major incidents (MI)

RADIOLOGIST
what exam? What diagnostic focus?

e-FAST – consider using to triage for CT in the initial phase

Trauma-protocol available on all scanners.

Ideally one standardized protocol for all for maximum efficiency

Consider WBCT in all patients requiring CT in mass casualty events (especially blast events) to avoid rescans

Basic imaging data to PACS, reading directly from modality console/workstation
Quick, concise documentation, standardized reporting - based on local practice (consider backup paper-based system)
Life-threatening findings must be reported immediately

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