Clinical Radiology

Major adult trauma radiology guidance

JUNE 2024

The Royal College of Radiologists

Contents

Recommendations

This standard of practice guideline is designed for severely injured adult patients presenting following major trauma. Separate paediatric-specific guidance can be found on the RCR website.[1]

1. The trauma team leader (TTL) is in overall charge in acute care.
2. Diagnostic imaging and intervention must be available and delivered by experienced staff.
3. Multidetector computed tomography (MDCT) should be adjacent to or in the emergency room. Where this is not the case:
    - Transfers must be rehearsed and performed according to protocol.
    - Simulation or rehearsal of patient transfers should be performed at regular intervals (at least once yearly).
    - Radiology departments in major trauma centres (MTCs) and trauma units (TUs) should plan to make this available in the near future.
4. Digital radiography (DR) must be available in the emergency room.
5. If there is an early decision to request multidetector computed tomography (MDCT), focused abdominal sonography in trauma (FAST) and digital radiography (DR) are not routinely required.
6. Magnetic resonance imaging (MRI) must be available with safe access for severely injured patients (SIPs).
7. A computed tomography (CT) request in the trauma setting should comply with the Ionising Radiation (Medical Exposure) Regulations 2020 (IR(ME)R) justification requirements in the same way as any other request for imaging involving ionising radiation.
8. There should be clear written protocols for multidetector computed tomography (MDCT) preparation and transfer to the scan room.
9. Whole-body contrast-enhanced multidetector computed tomography (MDCT) (Appendix 1) is the default imaging procedure of choice for severely injured patients (SIPs). Imaging protocols should be clearly defined and uniform across a regional trauma network.
10. Future planning and design of emergency departments should concentrate on increasing the number of severely injured patients (SIPs) stable enough for multidetector computed tomography (MDCT) and intervention.

11. A provisional primary survey report should be issued as soon as possible to the trauma team leader (TTL). This should be either as a signed paper copy (with a copy retained in the radiology department) or as an electronic pro forma on the radiology information system (RIS).
12. The final formal report on severely injured patients (SIPs) should be provided within one hour of multidetector computed tomography (MDCT) acquisition. This should be provided by a consultant radiologist or by an appropriately experienced radiology trainee, with a consultant addendum added within 24 hours.
13. On-call consultant radiologists must have teleradiology facilities at home that allow timely review of images.
14. Interventional radiology (IR) trauma teams should endeavour to begin treatment within 30 minutes of referral.
15. Interventional radiology (IR) facilities should be co-located with the emergency department or transfers must be rehearsed and follow defined protocols.
16. Angiographic facilities and endovascular theatres in major trauma centres (MTCs) should be safe environments for severely injured patients (SIPs) and should be of theatre standard.
17. Any deficiency in consumable equipment should be reported at the debriefing, be documented and be the subject of an incident report.
18. Where patients are transferred, there should be systems in place for locally acquired images to be transferred to the receiving hospital within one hour.
19. Severely injured patients (SIPs) should be discussed at regular multidisciplinary team meetings (MDTMs), with learning from events facilitated by an early debriefing and changes made to local protocols, as appropriate, to improve patient safety.

Introduction

This standard of practice guideline is designed for adult severely injured patients (SIPs) presenting following major trauma. Separate paediatric-specific guidance can be found on the RCR website.[1]

The purpose of this publication is to set standards for diagnostic and interventional radiology (IR) for use by major trauma centres (MTCs) and trauma units (TUs) relating to:

- How diagnostic imaging and IR services should be provided and used in the management of SIPs
- What quality indicators can be used for the provision of diagnostic imaging and IR in trauma
- Provision of protocols for imaging and reporting that can be adapted according to locoregional services
- Equipment requirements.

The standards are based upon the principle that the care provided to SIPs in the first few hours is critical to long-term recovery. Effective trauma care depends critically upon timely diagnostics and therapy.[2]

The standards will deal largely, but not exclusively, with SIPs following major trauma. Mechanism of injury, primary survey clinical examination and clinical observations all play a role in initial recognition and definition of SIPs. The injury severity score (ISS) is a retrospectively applied anatomical scoring system derived from imaging and clinical examination that assigns a value to injuries in different parts of the body using the abbreviated injury scale (AIS). An ISS greater than 15 is defined as major trauma. This would include serious injuries such as bleeding in the brain or pelvis and cases of multiple injuries, especially where the risk of haemodynamic instability is significant.[3] ISS and AIS are useful in predicting long-term morbidity and mortality but are not used in defining SIPs at the point of presentation. This requires careful clinical examination by an experienced trauma team.

Where trusts are not capable of providing the necessary level of service to adhere to these standards, protocols to transfer SIPs to an MTC should be in place.

The standards reflect consensus opinion based on available evidence and existing best practice. As stated, they are intended for local and regional consideration for adoption and adaptation according to current and future resources.

01 Standard 1

The trauma team leader (TTL) is in overall charge in acute care.

An acute trauma setting is not the place for disagreements about the patient pathway. Immediate management decisions must be made by the designated trauma team leader (TTL).

Major trauma centres (MTCs) and trauma units (TUs) will have multidisciplinary debriefings about severely injured patients (SIPs) on a regular basis to assess processes and adjust pathways if necessary. A radiologist involved in trauma management should attend such meetings. In addition, individual cases should be considered in the radiology department meetings on a regular basis.

02 Standard 2

Diagnostic imaging and intervention must be available and delivered by experienced staff.

Consultant led-care is the gold standard for severely injured patients (SIPs) following major trauma. Diagnostic and interventional radiology (IR) services should be consultant led where possible. Where this is not possible, for diagnostic imaging an appropriately experienced radiology trainee may provide the formal report, with a consultant radiologist issuing an addendum within a maximum of 24 hours. In cases where a radiology trainee is providing the initial report, a consultant diagnostic radiologist must be available 24 hours per day to review images immediately via teleradiology if requested by either the radiology trainee or clinical team.[4,5] A caveat should be added to the registrar's report indicating that a consultant review will be occurring. Once a consultant addendum has been added, robust systems should be in place to communicate this to the clinical team.

03 Standard 3

Multidetector computed tomography (MDCT) should be adjacent to or in the emergency room. Where this is not the case:

- Transfers must be rehearsed and performed according to protocols.
- Simulation or rehearsal of patient transfers should be performed at regular intervals (at least once yearly).
- Radiology departments in major trauma centres (MTCs) and trauma units (TUs) should plan to make this available in the near future.

The location of imaging facilities, their design and the equipment they contain should be based on the following principles.

- Timely injury identification and treatment is essential to good long-term outcomes in severely injured patients (SIPs). Any delay could lead to significant disability or death of the patient.
- Moving SIPs introduces delays and can exacerbate blood loss. Reducing the distance and number of times a patient is moved reduces their overall morbidity and mortality.
- Imaging SIPs has a significantly higher sensitivity and specificity at identifying injuries than clinical examination.
- The imaging technique of choice for SIPs is head-to-thigh contrast-enhanced multidetector computed tomography (MDCT).
- Definitive imaging should not be delayed by other, less accurate investigations (such as focused abdominal sonography in trauma [FAST] or digital radiography [DR]).
- The imaging environment requires all the life-support facilities that are available in the emergency room. This includes monitoring equipment and medical gases. The room design should allow visual and technical monitoring of the patient by anaesthetic staff during the scan.

04 Standard 4

Digital radiography (DR) must be available in the emergency room.

Both chest and pelvic X-rays can be useful in severely injured patients (SIPs) who are too unstable to be transferred to the computed tomography (CT) scanner. Pelvic X-ray is also indicated following removal of pelvic binders to assess for signs of pelvic instability, even after multidetector computed tomography (MDCT) has been performed.

SIPs often have extremity injuries that require evaluation with digital radiography (DR) in the emergency room after MDCT has been performed to aid definitive treatment planning.

05 Standard 5

If there is an early decision to request multidetector computed tomography (MDCT), focused abdominal sonography in trauma (FAST) and digital radiography (DR) are not routinely required.

Focused abdominal sonography in trauma (FAST) does not add any further information to that obtained from multidetector computed tomography (MDCT) and should not be performed if it would delay transfer to computed tomography (CT). FAST, like any ultrasound examination, is operator dependent and literature suggests very variable positive and negative predictive values for significant injury.[6,7] FAST does play an important role in triaging patients during major incidents when multiple severely injured patients (SIPs) present simultaneously.[8] The results of FAST should be documented in the patient's notes by the operator.

Once the decision is taken to proceed to MDCT, plain films of the abdomen, pelvis and spine are not required prior to CT. Extremity imaging should be delayed until life-threatening injuries have been diagnosed and treated. The British Orthopaedic Association and British Society of Spine Surgeons do not recommend plain films of the spine in SIPs, recommending CT imaging instead.[9]

If a pelvic binder has been in place during MDCT, a pelvic X-ray is indicated following removal of the pelvic binder to assess for signs of pelvic instability.

06 Standard 6

Magnetic resonance imaging (MRI) must be available with safe access for severely injured patients (SIPs).

Magnetic resonance imaging (MRI) is rarely indicated in the setting of acute trauma care except in specific cases, such as where there is concern about epidural haematoma. However, MRI should be available within 12 hours of presentation (or once the severely injured patient (SIP) is stable enough to be scanned), with the gold standard being MRI provision 24 hours a day, 7 days a week.[10,11] MRI should be available in the same building as the emergency department or, if it is in a different building, transfers should be rehearsed and performed according to protocol. A trauma unit (TU) without 24-hour access to MRI should have formal written protocols in place for transfer to the major trauma centre (MTC) or neurosciences centre to perform MRI.

Additional protocols should be in place to ensure safe MRI scanning and monitoring is achievable for intubated SIPs, which may involve transfer of the SIP to an MTC or neurosciences centre.

07 Standard 7

A computed tomography (CT) request in the trauma setting should comply with the Ionising Radiation (Medical Exposure) Regulations 2020 (IR(ME)R)[12] justification requirements in the same way as any other request for imaging involving ionising radiation.

The minimum expected clinical information provided on a multidetector computed tomography (MDCT) request should include:

- Mechanism of injury
- Primary survey findings and areas of concern
- Haemodynamic instability
- Results of any preceding investigations (such as focused abdominal sonography in trauma [FAST] or digital radiography [DR])
- Any significant medical or surgical history, if known
- Accurate contact details of the trauma team leader (TTL) or other responsible senior staff member.

Appendix 2 provides an example MDCT request pro forma, which may be modified according to local requirements.

An annual audit of MDCT requests in major trauma should be performed to ensure adherence to these regulations, with the results disseminated to the entire multidisciplinary team (MDT).

08 Standard 8

There should be clear written protocols for multidetector computed tomography (MDCT) preparation and transfer to the scan room.

There should be agreed local protocols with clear attribution of responsibility for every stage.

For severely injured patients (SIPs) with haemodynamic instability, an evaluation must be made of their suitability to undergo multidetector computed tomography (MDCT) rather than proceeding direct to theatre. Multidisciplinary discussion is often required in these cases, which may include the trauma team leader (TTL), consultant surgeon, anaesthetist, consultant radiologist and interventional radiologist. In centres with MDCT facilities co-located with the emergency department the number of patients deemed too unstable for MDCT should be very low.

Any issues that arise during transfer to MDCT must be discussed at regular debriefings and pathways modified accordingly.

Request for MDCT

Clear protocols must exist for notifying the computed tomography (CT) department of the need for urgent imaging and how the department will respond to ensure that the scanner is clear to receive the incoming SIP. It must be clear who is responsible for this at both ends.

Transfer route to CT

This must be established in advance, with advance notice given to staff required for safe patient transfer.

Intravenous (IV) access

Right antecubital access is preferred for contrast administration (left-sided injections compromise interpretation of mediastinal vasculature). A minimum cannula size of 18 G is required for pump injection. In cases of difficult IV access some 20 G and 22 G cannulas can tolerate pump injection of up to 3 millilitres of contrast per second (ml/s); however, manufacturer specification varies and local agreement will be required.

If arm vein access is not possible and a central line is *in situ*, this may be used, but it should be of a type that can accept 3 ml/s.[13] Many departments may have limited experience using central lines for pump injection so local negotiation may be required.

08

Standard 8

If IV access is not possible then intraosseous (IO) access may be used for contrast administration. Tibial and humeral IO contrast administration can provide good-quality diagnostic imaging and is able to tolerate flow rates of 4 ml/s via a power injector.[14,15] Care must be taken to ensure a focal unenhanced CT of the IO access site is performed prior to contrast administration to ensure this is correctly sited. Many departments may have limited experience using IO access for pump injection so local negotiation may be required.

Spinal injury

If a spinal injury is suspected, the patient should be appropriately immobilised prior to MDCT. Spinal immobilisation should not be routinely removed until the formal MDCT report is available. The primary survey report is not sufficiently detailed to radiologically clear the spine.

Pelvic fracture

If a pelvic fracture is suspected, a temporary pelvic stabilisation (eg wrap, binder) should be applied before MDCT.

Limb fractures

Only immediately limb-conserving manipulations or splinting should be performed prior to MDCT with rapid immobilisation such as air splints.

If CT lower limb angiography is being performed due to suspected vascular injury, any tourniquet must be removed or loosened prior to scanning to allow for adequate contrast opacification of the vessels. Ideally this should be done in the presence of the vascular surgical team to mitigate against any complications.

Urinary catheter

Urinary catheterisation is not generally indicated prior to MDCT but it may be useful in patients with clinically suspected significant pelvic injuries if it does not delay transfer to CT. If a urinary catheter is *in situ* then this should be clamped when delayed imaging is being performed to assess for urinary tract injury.

Pregnancy

There must be consideration of potential pregnancy status in SIPs of childbearing age. The decision to proceed to MDCT should be discussed between the clinical team and consultant radiologist and this decision documented. Given that the fetus is completely dependent on the parent, health of the pregnant patient should take priority and contrast-enhanced MDCT remains the gold standard in pregnant SIPs.

08

Standard 8

Bariatric patients

Bariatric patients can be particularly challenging to clinically assess and image in the major trauma setting. Knowledge of the weight limit and bore circumference of the CT scanner is vital in these patients. Most modern scanners have high weight limits, but the scanner bore is the most common limiting factor in these patients. A tape measure should be available in the emergency room to evaluate the patient prior to transfer to CT. A published list of weight limits and bore diameters of scanners within local networks should be available to help plan transfer of SIPs to appropriate centres for imaging.

Older or frail patients

Frail patients and those over the age of 65 years often have multiple co-morbidities, polypharmacy, delayed presentations and occult injuries following innocuous-sounding mechanisms of injury, all of which lead to higher levels of morbidity and mortality. Clinical examination can be limited in these patients, especially if they have memory impairment or communication difficulties. Even a fall from standing height can be a significant mechanism of injury in frail patients. Early recognition of traumatic injuries in this group is associated with improved long-term outcomes.[16,17] Thorough clinical assessment by an experienced TTL is essential in this cohort of patients to identify any areas of concern for significant injury. There should be a low threshold for MDCT in frail patients to identify occult injuries.

Thoracic injuries are an important consideration in this cohort of patients, with rib fractures having a significant morbidity and mortality in older patients. Identifying the extent of chest wall injuries and the location of rib fractures is important to ensure effective pain management. This allows appropriate therapies and planning of any appropriate definitive treatment.[18] Plain X-ray has a poor sensitivity to acute chest wall injuries so focal CT thorax may be appropriate in patients with clinically suspected isolated chest wall injury. Contrast-enhanced CT thorax should be used in any patient with suspected intrathoracic haemorrhage or in those with X-ray proven haemothorax or pneumothorax unless there is significant contraindication to the use of IV contrast. Non-contrast CT thorax may be considered in patients with suspected isolated chest wall injury, no clinical concern for associated haemorrhage and no anticoagulation use. The use of focal imaging protocols, particularly unenhanced scans, should be discussed between the TTL and radiologist.

There are increasing numbers of cases of physical abuse directed at frail and vulnerable adult patients. Radiologists should consider the possibility of carer abuse in patients with multiple injuries of different ages without a clear history.[19] Any concerns about carer abuse should be documented and discussed with the clinical team.

Blast injuries

Blast injuries are associated with significant visceral and bony injuries. Patients who have suffered blast injuries may appear clinically well on initial assessment and have chest radiographs that appear normal, but they can deteriorate rapidly.[20] Regular clinical review of these patients is essential to monitor for signs of deterioration, and there should be a low threshold for MDCT in this group. Imaging from head to toe should be considered as this patient group has a high incidence of occult embedded shrapnel.

09 Standard 9

Whole-body contrast-enhanced multidetector computed tomography (MDCT) (Appendix 1) is the default imaging procedure of choice for SIPs. Imaging protocols should be clearly defined and uniform across a regional trauma network.

Whole-body multidetector computed tomography (MDCT) in the setting of trauma is considered as imaging from the skull vertex to mid-thigh. MDCT has been shown to be a predictor of survival in severely injured patients (SIPs) when compared with no computed tomography (CT) or targeted CT.[21] Whole-body MDCT protocols should be designed to image a wide variety of injuries as clearly as possible. Protocols should be the same across networks so that repeat scanning is not required where transfer is necessary. Examples of polytrauma CT protocols are listed in Appendix 1.

10 Standard 10

Future planning and design of emergency departments should concentrate on increasing the numbers of severely injured patients (SIPs) stable enough for multidetector computed tomography (MDCT) and intervention.

As discussed in the standards above, co-locating diagnostic imaging and interventional theatres with the emergency department reduces delays in diagnosis and management leading to improved outcomes for severely injured patients (SIPs). Future design of upgrades to emergency departments should involve close consultation with radiology to ensure diagnostic equipment and interventional theatre are easily accessible.

11 Standard 11

A provisional primary survey report should be issued as soon as possible to the trauma team leader (TTL). This should be either as a signed paper copy (with a copy retained in the radiology department) or as an electronic pro forma on the radiology information system (RIS).

Reporting of multidetector computed tomography (MDCT) in the major trauma setting uses the Advanced Trauma Life Support (ATLS) system with an initial primary survey followed by a more detailed secondary survey (formal report). The aim of the primary survey is to indicate life-threatening injuries to ensure these are managed immediately. Examples include significant intracranial injury, airway compromise and active haemorrhage. An example provisional reporting pro forma is provided in Appendix 3.

The gold standard for a provisional report is for a consultant radiologist or appropriately experienced radiology trainee to attend the computed tomography (CT) control room and issue a contemporary report at the time of scanning. This provisional report should be either a signed paper form or an electronic pro forma on the radiology information system (RIS).

With the increasing use of regional on-call collaboratives and outsourcing to teleradiology companies this may not be possible. In these cases, a provisional report should be available within a maximum of 10 minutes from the time that the images are able to be reviewed remotely. This form of primary survey report must also be telephoned to the trauma team leader (TTL) or appropriate staff member in the emergency department in addition to being available on the RIS.[22,23] It is essential that contact details of the clinical team are provided on imaging requests to reduce communication delays. The time and date of this provisional report should be documented, in addition to the name and role of the clinical team member informed and any difficulties in contacting the clinical team.

Spinal and pelvic immobilisation should not be routinely removed based on the results of this provisional report. These should only be removed following the formal report being issued alongside careful clinical examination. Pelvic X-ray is recommended after binder removal to assess for any signs of pelvic instability.

12 Standard 12

The final formal report on severely injured patients (SIPs) should be provided within one hour of multidetector computed tomography (MDCT) acquisition. This should be provided by a consultant radiologist or by an appropriately experienced radiology trainee, with a consultant addendum added within 24 hours.

Once the provisional primary survey report has been issued, the multidetector computed tomography (MDCT) images should be carefully reviewed against a set of agreed written criteria and a formal final report issued within one hour of the images being available on the picture archiving and communication system (PACS). Any new significant findings identified at this secondary review should be telephoned to the clinical team. Appendix 4 is an example of a reporting template to be used for this final formal report.

The gold standard is for this final formal report to be issued by a consultant radiologist. In cases where this is not possible, the final report may be issued by an appropriately experienced radiology trainee with a consultant radiologist addendum added within a maximum of 24 hours.[4] Robust systems should be in place to communicate this consultant addendum to the clinical team. In cases where a radiology trainee is providing the initial report, a consultant diagnostic radiologist must be available 24 hours per day to review images immediately via teleradiology if requested by either the radiology trainee or clinical team.[22] In cases where a radiology trainee issues the formal report, a caveat should be added to the report explaining that a consultant addendum will be available. In any cases where the reviewing consultant radiologist disagrees with the registrar's report, these findings must be telephoned to the clinical team by the consultant radiologist and feedback given to the reporting registrar.[23] These cases should also be discussed at regular debriefings and departmental radiology events and learning meetings (REALMs).[24]

In major incidents when multiple severely injured patients (SIPs) are scanned in a short period of time, an abbreviated formal report may be issued outlining the key injuries. Arrangements should be in place for these scans to have a more formal review in a less time-pressured manner once the major incident is over to identify any additional findings and communicate these to the clinical team.

13 Standard 13

On-call consultant radiologists must have teleradiology facilities at home that allow timely review of images.

Standard 13 ensures that standards 11 and 12 can be safely achieved. Since the COVID pandemic, the provision of home reporting workstations is standard in the majority of UK trusts.[25]

14 Standard 14

Interventional radiology (IR) trauma teams should endeavour to begin treatment within 30 minutes of referral.

Where evidence of arterial injury is present, the on-call interventional radiologist should be informed immediately along with the trauma team leader (TTL). Where findings are equivocal, the on-call consultant diagnostic radiologist should be asked for an immediate opinion.

The decision on whether a patient with traumatic vascular injury undergoes endovascular treatment, open surgery, a combination of the two or non-operative management (NOM) is typically made by discussion between the TTL, interventional radiologist, consultant surgeon and anaesthetist. Decisions must be made quickly and should be driven by agreed algorithms. Establishing routes of communication between the key services is paramount. Patients often require resuscitation prior to transfer to hybrid theatres or interventional radiology (IR) suites. Once the decision has been made for endovascular treatment, the IR team should be available to begin this within 30 minutes.

Adequate staffing levels (interventional radiologist, radiographer and nursing staff) must be available. Much trauma occurs outside normal working hours and the best clinical outcomes are achieved by rapid access to consultant-led and delivered IR services. If resident on-call IR staff are not considered necessary locally, early warning systems for on-call IR teams should be in place. The priority must be to develop systems that reduce the total time to arrest of haemorrhage. There are high costs in establishing and running a 24/7 IR service, but these can result in significant cost savings compared with alternative surgical treatments.[26,27,28]

15 Standard 15

Interventional radiology (IR) facilities should be co-located with the emergency department or transfers must be rehearsed and follow defined protocols.

Similar to Standard 3, the shorter the distance severely injured patients (SIPs) are moved for intervention the lower the risk of delay and associated adverse outcomes. When interventional radiology (IR) is indicated in SIPs, rapid access to endovascular treatment is essential to minimise the time to arrest of haemorrhage. Angiographic and endovascular facilities should be located as close as possible to the emergency department, and future planning should aim to have acute theatre complexes co-located with the emergency department capable of both surgical and endovascular treatments with adequate anaesthetic support. Such complexes are currently not widely available in the UK.

16 Standard 16

Angiographic facilities and endovascular theatres in major trauma centres (MTCs) should be safe environments for severely injured patients (SIPs) and should be of theatre standard.

Angiography suites must have up-to-date (installed within the last ten years) fixed C-arm imaging equipment. Rooms need to be large enough to handle the numerous individuals who accompany very unstable trauma patients. They should have the same facilities as an operating theatre with up-to-date anaesthetic equipment and ideally should have positive pressure air change.[29]

Portable C-arm equipment should only be used in the context of immediate stabilisation by occlusion balloon inflation. Portable units do not offer the same imaging quality as fixed units and there is evidence of patient harm occurring with the use of such units, principally due to poor image quality. In addition, portable units can only operate for a limited time before overheating. Interventional procedures should not routinely be performed outside of a dedicated angiographic suite.

Local services should take particular care to develop transfer protocols for both internal and external anaesthetic-supported transfer. A frequent source of delay in many centres is the internal transfer of haemodynamically compromised patients for computed tomography (CT) imaging or embolisation. Agreed pathways and improvements to the local environment should be prioritised to minimise delay while maintaining patient safety.

17 Standard 17

Any deficiency in consumable equipment should be reported at the debriefing, be documented and be the subject of an incident report.

There should be a full range of occlusion balloons, catheters, embolic materials and stent grafts available and there should be a robust system in place for replacement of used items. The use of embolisation packs is particularly recommended, especially on very rare occasions when procedures are being undertaken outside the routine angiographic environment.

18 Standard 18

Where patients are transferred, there should be systems in place for locally acquired images to be transferred to the receiving hospital within one hour.

Sometimes patients may need to be transferred from one unit to another, for example from a trauma unit (TU) to a major trauma centre (MTC), and unnecessary repeat investigations should be avoided. All current relevant images should be transferred with the patient as securely as possible. This is best achieved using an image exchange portal (IEP).

19 Standard 19

Severely injured patients (SIPs) should be discussed at regular multidisciplinary team meetings (MDTMs), with learning from events facilitated by an early debriefing and changes made to local protocols, as appropriate, to improve patient safety.

Patients often have complex injuries, with a large range of specialties and non-clinical staff involved with the patient's care. Incidental findings may also be seen in around 25–40% of patients, with approximately 15% being defined as major. However, in reviews, only a small proportion of these are followed up.[30] Regular multidisciplinary team meetings (MDTMs), as in other services, are required to ensure good communication and holistic management of patients.

The gold standard is for daily, clinically led MDTMs reviewing all major trauma calls from the preceding 24 hours and any significant updates on major trauma inpatients. Consultant-led discussion is essential in these MDTMs, with input from consultants in radiology, general or trauma surgery, orthopaedics and anaesthetics or intensive care being considered mandatory. Input from other specialties such as neurosurgery, spinal surgery, general medicine and rehabilitation medicine are also very useful if available locally (or via video link). Allied healthcare professionals including physiotherapy, occupational therapy, psychology and ward nursing staff also play an important role in these MDTMs.

The daily MDTM also allows a 'third read' of multidetector computed tomography (MDCT) imaging from severely injured patients (SIPs) by a consultant radiologist (in addition to the provisional primary survey report and final report). This is in a less time-pressured environment and can be directed to areas of concern highlighted at the secondary and tertiary clinical surveys. This third read has been shown to be beneficial, identifying previously unreported injuries in up to 33% of cases.[30]

Regular formal debriefings should also take place to discuss any issues arising from individual cases. It is recommended that these are performed monthly and additional debriefings should take place following any major incident. Radiologists and radiographers should be invited to attend these meetings.

Additional considerations

Simulation

Simulation of major trauma allows teams to rehearse unusual as well as more commonly encountered scenarios in a controlled manner so that units are better prepared, and it should be routinely performed in major trauma centres (MTCs) and trauma units (TUs). In 2009, a previous Chief Medical Officer, Sir Liam Donaldson, issued a directive on simulation, which has led to the creation of dedicated simulation centres for training a wide variety of healthcare staff.

Artificial intelligence (AI)

AI is a rapidly expanding area within radiology and there are currently multiple AI systems in development to aid diagnostic and interventional radiologists in a trauma setting. There are currently no AI systems widely used in the UK. The field of AI is rapidly changing and any systems that are proven to benefit patients should be encouraged. AI systems are likely to be evaluated further in future versions of this guideline.

Audit and morbidity and mortality meetings

Multidisciplinary team audit, including all involved specialties, is essential to improve and maintain high-quality clinical services. Radiologists should ensure they participate in ongoing audit of trauma services and contribute to local and national audit mechanisms.

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A1 Examples of polytrauma protocols

For paediatric trauma patients, refer to the RCR's separate paediatric-specific guidance.[1]

Example 1

- Remove radio-opaque objects from the gantry
- Head towards gantry (do not use head rest)
- Place monitoring equipment outside of the gantry where possible or at least outside of the field of view (over the lower limbs)
- Arm position is dependent on patient status
- No indication for oral contrast, water or rectal contrast for initial scan

Head – routine unenhanced brain

- Lateral topogram
- 1 mm contiguous axial slices of cranium (soft tissue/brain algorithm)
- 1 mm contiguous axial slices of cranium (bone algorithm)

Neck and chest

- 100 ml contrast 300 @ 3.5 ml/s
- Right antecubital vein 18 gauge if possible (see Standard 8 for comment on central line and intraosseous [IO] access for contrast administration)
- 30-second delay
- Skull base to diaphragm
- Reconstructions: contiguous axial 1 mm soft tissue and bone algorithms

Abdomen and pelvis

- Diaphragm to pubic ramus (including whole of the liver)
- 70-second delay from start of injection
- Reconstructions: contiguous axial 1 mm soft tissue and bone algorithms

Example 2

The above protocols can be modified using a biphasic protocol to obtain venous and arterial phases in a single scan.

Biphasic protocol

1. Unenhanced spiral brain 1 mm (brain and bone algorithms); 5 mm reconstructions immediately available for review.
2. Circle of Willis to symphysis pubis (bone and soft tissue algorithms)
   - 150 ml biphasic contrast injection – initial 65 ml at 2 ml/s then 85 ml at 3.5 ml/s
   - Scan starts at 60 seconds

   This gives portal venous enhancement with good arterial contrast at the same time and the scan can be carried on down the legs if necessary. The cervical contrast has been very useful both for penetrating injury and for spinal injury or vertebral artery.
3. The use of delayed scans limited to specific cases at the request of radiologist.

Special circumstances

Hanging

In severely injured patients (SIPs) presenting following ligature injuries to the neck, contrast-enhanced imaging of the neck is essential as these patients have a high risk of vascular injuries. Extending the contrast-enhanced scan to include the brain can also be useful to assess for associated intracranial vascular compromise.

Iodinated contrast allergy

In SIPs with a known allergy to intravenous (IV) iodinated contrast an unenhanced scan may be performed as this will identify significant pathologies.

Suspected urinary tract injury

If there is high clinical suspicion or the initial multidetector computed tomography (MDCT) identifies a urinary tract injury then delayed imaging can be useful to identify contrast extravasation from the urinary tract. An additional unenhanced acquisition of the abdomen and pelvis following MDCT (up to one hour afterwards) can show extravasation of the initial contrast bolus.

Code red and penetrating injuries

Code red trauma and penetrating injuries suggest a high risk of vascular injury. Split bolus imaging is essential in these patients to identify active bleeding. Triple-phase imaging may be appropriate in certain cases, which will require discussion between the trauma team leader (TTL) and radiologist.

A2 Sample whole-body trauma CT request form

Patient name:			
Address:		DOB:	
		Sex:	
Consultant:		Contact phone number/bleep:	
Indication			
RTA	Injury to more than one body region		
	Fatality at scene		
	High speed impact		
Fall	Injury to more than one body region		
	Fall from over 3 m		
Assault	Injury to more than one body region		
Reduced GCS with unknown mechanism of injury			
Other/additional info			
Current GCS			
Haemodynamically	Stable	Unstable	
Clinical regions of concern			
Head		Abdo pelvis	
C-spine		All	
Thorax		None	
Clinical questions to be answered:			
LMP		Catheterised	
Referring doctor and contact phone number/bleep		Date	
Signature			

A3 CT primary assessment

Patient name:	
Date of scan:	
Reporting radiologist:	
Purpose:	To guide initial management only. Formal detailed report will follow on results server.

Airway

ET placement	N/A	Satisfactory	Unsatisfactory
Airway obstruction		Yes	No

Breathing

Pneumothorax		Yes	No
Haemothorax		Yes	No
Contusion		Yes	No
Laceration		Yes	No
Chest drain placement	N/A	Satisfactory	Unsatisfactory

Circulation (bleeding)

Thoracic	Yes	No
Abdominal	Yes	No
Pelvic	Yes	No
Soft tissue	Yes	No

Disability

Intracranial bleed/oedema	Yes	No
Major spinal injury	Yes	No
Pelvic fractures	Yes	No

Other

A4 Secondary trauma report

Date:		Time:	
Name:		DOB:	
Patient ID no:			

CT head	
C-spine	
Thoracolumbar spine	
Pelvic bones	

CHEST	
Airway	
Lungs	
Pleural spaces	
Vascular injury	
Mediastinum and heart	
Diaphragm	
Chest wall (ribs and sternum)	
Shoulders	
Other/incidental findings	

ABDOMEN\PELVIS	
Free gas	
Free fluid	Haemoperitoneum
Vascular injury	
Liver	
Spleen	
Kidneys	
Pancreatobiliary	
Adrenal	
Bowel and mesentery	
Retroperitoneum	
Bladder	
Abdominal wall	
Other/incidental findings	
Delayed imaging (if applicable)	

CONCLUSION	
Additional text sheet	Yes/No
Reported by:	
Emailed to:	

Glossary

AI	Artificial intelligence
AIS	Abbreviated injury scale
ATLS	Advanced Trauma Life Support
CT	Computed tomography
DR	Digital radiography
FAST	Focused abdominal sonography in trauma
IEP	Image exchange portal
IR	Interventional radiology
ISS	Injury severity score
MDCT	Multidetector computed tomography
MDT	Multidisciplinary team
MRI	Magnetic resonance imaging
MTCs	Major trauma centres
NOM	Non-operative management
PACS	Picture archiving and communication system
RCR	The Royal College of Radiologists
REALM	Radiology events and learning meetings
RIS	Radiology information system
SIP	Severely injured patient
TTL	Trauma team leader
TUs	Trauma units

Acknowledgements

We are very grateful to the working group who led on the development of this publication.

Working group members

Chair: Christopher McLeavy, Consultant Radiologist, Liverpool University Hospitals NHS Foundation Trust and President of British Society of Emergency Radiology (BSER)

William Boswell, Consultant Radiologist, Liverpool University Hospitals NHS Foundation Trust

Lenetta Boyce, Consultant Radiologist, Liverpool University Hospitals NHS Foundation Trust

Aldo Camenzuli, Consultant Interventional Radiologist, Liverpool University Hospitals NHS Foundation Trust

Sumita Chawla, Consultant Gastrointestinal and Trauma Radiologist, Medical Director Diagnostic and Clinical Support Services, Liverpool University Hospitals NHS Foundation Trust

Michelle Christie-Large, Consultant Musculoskeletal and Trauma Radiologist, University Hospital Coventry & Warwickshire NHS Trust

Marcela De La Hoz Polo, Consultant Musculoskeletal and Trauma Radiologist, Everlight Radiology

Radhika Prasad, Consultant Radiologist, Liverpool University Hospitals NHS Foundation Trust

David Tennant, Consultant Radiologist, Medica

The Royal College of Radiologists
63 Lincoln's Inn Fields
London, WC2A 3JW, UK

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+44 020 7405 1282
enquiries@rcr.ac.uk
rcr.ac.uk

@RCRadiologists

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The Royal College of Radiologists. *Major adult trauma radiology guidance*. London: The Royal College of Radiologists, 2024. Previously published as *Standards of practice and guidance for trauma radiology in severely injured adult patients*.

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