

# Standards of practice and guidance for trauma radiology in severely injured patients

Second edition

Faculty of Clinical Radiology

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### RCR Standards

The Royal College of Radiologists (RCR), a registered charity, exists to advance the science and practice of radiology and oncology.

It undertakes to produce standards documents to provide guidance to radiologists and others involved in the delivery of radiological services with the aim of defining good practice, advancing the practice of radiology and improving the service for the benefit of patients.

The standards documents cover a wide range of topics. All have undergone an extensive consultation process to ensure a broad consensus, underpinned by published evidence where applicable. Each is subject to review four years after publication or earlier if appropriate.

The standards are not regulations governing practice but attempt to define the aspects of radiological services and care which promote the provision of a high-quality service to patients.

All of the standards produced by the RCR can be found on the College website at [www.rcr.ac.uk/standards](http://www.rcr.ac.uk/standards)

### Francis classification of RCR standards

- Fundamental standards of minimum safety and quality in respect of which non-compliance should not be tolerated. Failures leading to death or serious harm should remain offences for which prosecution can be brought against organisations. There should be a defined set of duties to maintain and operate an effective system to ensure compliance.
- Enhanced quality standards: such standards could set requirements higher than the fundamental standards, but would be discretionary matters for commissioning and subject to availability of resources.
- Developmental standards which set longer term goals for providers: these would focus on improvements in effectiveness and are more likely to be the focus of commissioners.<sup>1</sup>

## Foreword

The Royal College of Radiologists (RCR) would like to acknowledge the contribution of the Faculty of Clinical Radiology, the Professional Support and Standards Board and, in particular, Dr Raman Uberoi and Dr Sam Chakraverty for their individual work on the revision of these standards. Some progress has been made since the original publication of this document but much more work and investment are required to provide trauma imaging to the highest international standards.

This document should be read in conjunction with the RCR document on *Paediatric trauma protocols*.<sup>2</sup>

This document replaces *Standards of practice and guidance for trauma radiology in severely injured patients* (BF CR[11]13) which has now been withdrawn. The standards contained within this document fall within the enhanced category as defined by the Francis report, see Francis classification of RCR standards (page 2).<sup>1</sup>

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### Current standards documents

*Standards for intravascular contrast administration to adult patients, Third edition*

*Standards for the provision of an ultrasound service*

*Standards of practice of computed tomography coronary angiography (CTCA) in adult patients*

*Cancer multidisciplinary team meetings – standards for clinical radiologists, Second edition*

*Standards for Learning from Discrepancies meetings*

*Standards for radiofrequency ablation (RFA), Second edition*

*Standards for patient confidentiality and PACS and RIS*

*Standards for the communication of critical, urgent and unexpected*

*significant radiological findings, Second edition*

*Standards for patient consent particular to radiology, Second edition*

*Standards of practice and guidance for trauma radiology in severely injured patients*

*Standards and recommendations for the reporting and interpretation of imaging investigations by non-radiologist medically qualified practitioners and teleradiologists*

*Standards for the NPSA and RCR safety checklist for radiological interventions*

*Standards for the provision of teleradiology within the United Kingdom*

*Standards for the recording of second opinions or reviews in radiology departments*

*Standards for a results acknowledgement system*

*Standards for providing a 24-hour diagnostic radiology service*

*Standards for providing a 24-hour interventional radiology service*

*Standards for Self-assessment of Performance*

*Standards for the Reporting and Interpretation of Imaging investigations*

*Standards for Ultrasound Equipment*

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## Recommended standards

### Standard 1

The trauma team leader is in overall charge in acute care.

### Standard 2

Protocol-driven imaging and intervention must be available and delivered by experienced staff. Acute care for severely injured patients (SIPs) must be consultant delivered.

### Standard 3

Multi-detector 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
- Radiology departments in major trauma centres (MTCs) and trauma units (TUs) should plan to make this available in the near future.

### Standard 4

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

### Standard 5

If there is an early decision to request MDCT, focused abdominal sonography in trauma (FAST) and DR should not cause any delay.

### Standard 6

Magnetic resonance imaging (MRI) must be available with safe access for the SIP.

### Standard 7

A computed tomography (CT) request in the trauma setting should comply with the *Ionising Radiation (Medical Exposure) Regulations 2000 (IR(ME)R)* justification regulations in the same way as any other request for imaging involving ionising radiation.<sup>3</sup>

### Standard 8

There should be clear written protocols for MDCT preparation and transfer to the scan room.

### Standard 9

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

### Standard 10

Future planning and design of emergency rooms should concentrate on increasing the numbers of SIPs stable enough for MDCT and intervention.

### Standard 11

The primary survey report should be issued immediately to the trauma team leader. It should be signed and designated and a copy should be retained in the CT department (or radiology information system [RIS]).

### Standard 12

On-call consultant radiologists should provide the final report on the SIP within one hour of MDCT image acquisition.

### Standard 13

On-call consultant radiologists must have teleradiology facilities at home that allow accurate reports to be issued within one hour of MDCT image acquisition.

### Standard 14

Interventional radiology (IR) facilities should be co-located to the emergency department.

### Standard 15

Angiographic facilities and endovascular theatres in MTCs should be safe environments for SIPs and should be of theatre standard.

### Standard 16

Agreed written transfer protocols between the emergency department and imaging/interventional facilities internally or externally must be available.

### Standard 17

IR trauma teams should be in place within 60 minutes of the patient's admission or 30 minutes of referral.

### Standard 18

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

### Standard 19

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

### Standard 20

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

'All regions should be moving trauma service provision into regional trauma network configurations in 2011/12. Tariff changes will be introduced from April 2011 that are designed to recompense for the complexity of multiple-injury patients. Designated major trauma centres should be planning the continuous provision of consultant led trauma teams, immediate computed tomography (CT) scan options, and access to interventional radiology services for haemorrhage.'

*The Operating Framework for the NHS in England 2011/12<sup>4</sup>*

15 December 2010

## 1. Introduction

This standard of practice guideline is intended to complement the NHS report, *Regional Networks for Major Trauma*, to which Fellows of The Royal College of Radiologists (RCR) contributed through the NHS Clinical Advisory Groups (CAGs) report on regional trauma networks.<sup>5,6</sup> These standards of practice are written with the support of the National Clinical Director for Trauma Care, under whose leadership the NHS CAG report was developed. These standards and guidelines should be read in conjunction with the NHS CAG publication which states the definitions and principles on which this set of standards is based.<sup>5</sup>

Although these standards are aimed at the management of severely injured patients (SIPs) in England, a similar standard of care is appropriate in managing severely injured patients in other parts of the UK.

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

- How diagnostic imaging and interventional radiology services should be provided and used in the management of the severely injured patient
- When diagnostic imaging and interventional radiology are appropriate and when they are contraindicated
- What quality indicators can be used in the provision of diagnostic imaging and interventional radiology for trauma
- Provision of protocols for imaging and reporting that can be adapted according to loco-regional service requirements and equipment.

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

They are based on the principle that the care provided to the trauma patient in the first few hours can be absolutely critical in terms of predicting longer-term recovery and that good trauma care involves getting the patient to the right place at the right time for the right treatment. The standards also recognise that in the overall management of the severely injured patient, from roadside to rehabilitation, diagnostic and therapeutic radiology play a pivotal role but form a small part of the whole management process.

The standards will deal largely but not exclusively with SIPs following major trauma. NHS Choices defines major trauma as 'multiple, serious injuries that could result in death or serious disability'.<sup>7</sup> Serious injuries might include serious head injuries, severe gunshot wounds, falls, crush injuries or road traffic accidents.

Major trauma is defined in the scientific literature using the injury severity score (ISS).<sup>8</sup> The ISS is an anatomical scoring system derived from imaging and clinical examination which assigns a value to injuries in different parts of the body using the abbreviated injury scale (AIS).<sup>9</sup> The highest scores from three different body regions are used to calculate a figure representing the severity of injury. An ISS greater than 15 is defined as major trauma. This would include serious injuries such as bleeding in the brain or a fracture of the pelvis and cases of multiple injuries, especially where the risk of haemodynamic instability is a consideration.

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

The 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.

### Standard 1

The trauma team leader is in overall charge in acute care.

#### Quality indicator

MTCs and TUs will have multidisciplinary debriefings about 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 on a regular basis.

## 2. Imaging and intervention

### Radiologists

Just as the trauma team leader must be an experienced consultant, there must also be consultant-delivered input for imaging and intervention.

### Standard 2

Protocol-driven imaging and intervention must be available and delivered by experienced staff. Acute care for SIPs must be consultant delivered.

### Location and facilities

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

- Speed is of the essence – time is tissue, time is organs, time is life; delay is deterioration, disability and death
- Moving an SIP introduces delays and can exacerbate blood loss. The less the patient is moved and the shorter the distance, the greater will be the chance of survival
- Imaging in SIPs more accurately delineates the extent of injury than clinical examination
- The imaging technique of choice is the one which is definitive in the trauma setting. In SIPs this will most often be head-to-thigh contrast-enhanced multi-detector computed tomography (MDCT)
- Definitive imaging should not be delayed by other, less accurate investigations
- The imaging environment requires all the life-support facilities which are available in the emergency room. This will include monitoring and gases. The room design should allow visual and technical monitoring of the patient by anaesthetic staff.

### Standard 3

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
- Radiology departments in MTCs and TUs should plan to make this available in the near future.

### Digital radiography

Digital radiography (DR) must be available in the emergency room. A chest X-ray (CXR) might precede an MDCT scan if there is doubt about the side or presence of a pneumothorax in a patient with respiratory compromise. Once the decision is taken to request an emergency MDCT, plain films of the abdomen or pelvis are usually irrelevant and 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 cervical-spine in SIPs and their standard of practice for cervical-spine clearance is CT.<sup>10</sup>

Cervical spinal injury precautions and pelvic binders should remain in place until the MDCT has been fully assessed.

Where severe injury is to the spine only, MDCT or an MRI scan might be required but a plain-film series of the cervical spine might also be indicated.

#### Standard 4

Digital radiography must be available in the emergency room.

### FAST

Focused abdominal sonography in trauma (FAST) does not add any further information to that obtained from a CT scan and should not be performed if it would delay transfer to CT. FAST is a poor discriminator of the requirement or otherwise for laparotomy in trauma. Studies have shown negative predictive values of only 50–63% for FAST in unstable patients.<sup>11,12</sup> FAST does have value in the diagnosis of pericardial effusion and, in experienced hands, might detect free intra-abdominal fluid in an otherwise non-compromised patient. It has an important role in triage when managing multiple SIPs simultaneously or in a major incident scenario. As with all imaging, a report on a FAST scan should be documented and the designation of the operator recorded. In computerised triage of calls, SIPs must be given top priority and it should be confirmed explicitly when a patient can be safely received by the imaging department.

#### Standard 5

If there is an early decision to request MDCT, FAST and DR should not cause any delay.

#### Quality indicator

Where FAST or plain films have been used in an SIP, their use and value in that case should be evaluated in a multidisciplinary debriefing.

### Magnetic resonance imaging (MRI)

MRI is not indicated in the setting of acute trauma care. However, in the MTC, it must be available 24 hours a day, seven days a week. It should be in the same building as the emergency department or, if it is in a different building, protocols should be in place for the transfer of critically injured patients if further management is dependent on MRI in the first 12 hours. In a TU without access to 24-hour MRI, formal written protocols should be in place for the transfer of patients to a facility that has 24-hour MRI.

#### Standard 6

MRI must be available with safe access for the SIP.

#### Quality indicator

Availability of clear protocols for the transfer of SIPs to MRI facilities within 12 hours.

### 3. Indications for imaging in the SIP

As stated above, there may be indications for plain DR but these should never delay an MDCT if a decision has been taken early that this is the imaging modality of choice. There may be circumstances where imaging is inappropriate; for example, where an SIP is admitted with profound shock, is not responding to intravenous fluids and the site of bleeding is clear from the mechanism of injury and rapid assessment. Such patients may be best taken straight to theatre. The more accessible the MDCT scanner is to the emergency room and the more efficient CT transfer organisation is, the less frequently this should happen.

A polytrauma protocol MDCT is indicated when:

- There is haemodynamic instability
- The mechanism of injury or presentation suggests that there may be occult severe injuries that cannot be excluded by clinical examination or plain films
- FAST (if used) has demonstrated intra-abdominal fluid
- Plain films suggest significant injury, such as pneumothorax or pelvic fractures
- There is obvious severe injury on clinical assessment.

#### Standard 7

A CT request in the trauma setting should comply with the *Ionising Radiation (Medical Exposure) Regulations 2000 (IR(ME)R)* justification regulations in the same way as any other request for imaging involving ionising radiation.<sup>3</sup>

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#### Quality indicator

An annual audit of justification in trauma imaging should be carried out by the radiology department.

Appendix 2 demonstrates a sample request card which trusts can modify according to local needs.

NOTE: Some MTCs in other European and North American countries have adopted a 'CT-first' protocol. The UK awaits the results of the randomised study of early assessment by CT scanning in trauma patients (REACT) trial, currently recruiting patients to a CT-first or resuscitation-first protocol in the Netherlands.<sup>13</sup> The result of that study might supersede the indications above and major trauma itself may justify immediate MDCT, delaying only in the resuscitation area for time-critical interventions such as securing an airway or profound hypotension.

## 4. Preparation and transfer to MDCT

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

### Request for MDCT

Clear protocols must exist for notifying the 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 injured patient. It must be clear who is responsible for this at both ends. There should be a detailed polytrauma request form (see Appendix 2).

### Transfer route to CT

This must be established in advance. Transfer staff should be notified well in advance.

### Intravenous access

Right antecubital access is preferred for contrast administration (left-sided injections compromise interpretation of mediastinal vasculature). However, if arm vein access is not possible and a central line is *in situ*, it should be of a type that can accept 4 millilitres (ml) of contrast/second via a power injector. This might require local negotiation with emergency department doctors beforehand.

### Pelvic fracture

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

### Limb fractures

Only immediately limb conserving manipulations/splinting should be performed prior to CT with rapid immobilisation such as air splints.

### Urinary catheter

All SIPs without obvious contraindications should be catheterised unless this would delay transfer to CT. The catheter should be clamped prior to MDCT.

### Pregnancy

There must be awareness of pregnancy status in female SIPs of childbearing age. The health of the mother takes precedence over the health of the fetus and, if appropriate, modification of pathways should be decided by the trauma team leader and consultant radiologist.

### Standard 8

There should be clear written protocols for MDCT preparation and transfer to the scan room.

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### Quality indicator

Written protocols should be available for MDCT and patient transfer, with discussion of any problems that arise during this process at the debriefing.

## 5. MDCT imaging protocols

Whole-body MDCT has been shown to be a predictor of survival in SIPs when compared to no CT or targeted CT.<sup>14</sup>

Clearly there are many abnormalities that might be detected on whole-body MDCT in the SIP and protocols should be designed to image these as clearly as possible. Protocols should be the same across networks so that repeat scanning is not required where transfer is necessary.

Where active contrast extravasation is seen, the on-call interventional radiologist should be informed immediately along with the trauma team leader. Where findings are equivocal, the on-call consultant radiologist should be asked for an immediate opinion.

Examples of polytrauma CT protocols are listed in Appendix 1. An MDCT protocol should be agreed across a trauma network to ensure consistency and obviate the need for repeat scanning if transfer is necessary.

The NHS CAG document refers to the patient who is 'stable enough to undergo MDCT'.<sup>5</sup> The phrase used reflects the difficulty in being too prescriptive in giving guidance about the stability of an SIP and fitness for investigation. It can be argued that the greater the haemodynamic instability, the greater the requirement for accurate diagnosis to allow targeted surgery/intervention. In the perfect emergency room environment where all imaging is immediately co-located, there should be a very small minority of patients too unstable for MDCT. Such patients would probably require open procedures in the emergency room environment. However, local circumstances will vary and undoubtedly such

decisions have to be made at the time by the trauma team leader after consultation.

Protocols for unstable patient transfer should take account of unit geography and be rehearsed to maximise the proportion of patients who can access CT.

### Standard 9

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

### Standard 10

Future planning and design of emergency rooms should concentrate on increasing the numbers of SIPs stable enough for MDCT and intervention.

### Quality indicator

Imaging and reporting protocols should be agreed across referral regions and written protocols must be available.

## 6. Reporting

The initial MDCT should be attended by an appropriately trained on-call radiologist. Trainees should involve on-call consultant radiologists as soon as possible.

Reporting follows the advanced trauma life support (ATLS) system in that there should be an initial primary survey followed by a secondary survey.<sup>15</sup>

### Initial primary survey review

The aim of this is to give an immediate indication of the major life-threatening injuries while active management continues. The initial images should be reviewed looking for thoracic injuries that might impair breathing, vascular injuries that might cause bleeding and neurological injuries that might cause disability if not treated rapidly. A suggested CT primary survey pro forma is provided in Appendix 3. Such a form should be filled in at the time, signed and dated. A copy should be handed to the trauma team leader and a duplicate scanned into the radiology information system (RIS).

The clinical team should fill in their contact details so that when the full trauma pro forma report is completed, all the necessary points of contact are available.

### Standard 11

The primary survey report should be issued immediately to the trauma team leader. It should be signed and designated and a copy should be retained in the CT department (or RIS).

## 7. Secondary/definitive survey

Once the initial scan results and pro forma have been communicated to the trauma team, the scan should be carefully reviewed against a written set of criteria and the completed secondary trauma report (Appendix 4). This should be performed by a consultant radiologist or in consultation with a consultant radiologist who may provide this report via a teleradiology link of suitable quality.<sup>16</sup>

NOTE: Radiologists working remotely for teleradiology companies have imaging equipment that allows diagnostic reports in real time and the UK military have reporting facilities in the UK that allow accurate reporting of trauma scans from field hospitals anywhere in the world, although they do deploy radiologists on site to cope with rapid fluctuations in patient care.

All the areas listed in Appendix 4 should be reported on. This report should be completed within one hour to ensure there is no unnecessary delay to clinical management. Any significant findings, particularly where there is a variance to the initial primary survey report, should be telephoned through to relevant clinicians. Again, the list of contact details will be invaluable where there is a change in findings.<sup>17</sup>

### Standard 12

On-call consultant radiologists should provide the final report on the SIP within one hour of MDCT image acquisition.

### Standard 13

On-call consultant radiologists must have teleradiology facilities at home that allow accurate reports to be issued within one hour of MDCT image acquisition.

### Quality indicator

All imaging should be discussed at debriefing meetings and errors of protocol or fact discussed at discrepancy meetings.<sup>18</sup>

## 8. Interventional radiology (IR)

The role of IR in the SIP is to stop haemorrhage as quickly as possible with minimal interference to the patient's already damaged physiology. It is as much a form of damage control as pressing on a bleeding artery or surgical packing. Information supplied by MDCT is key to informing the decision-making process and guiding a catheter to the haemorrhage site. It is likely that there will never be Level 1 evidence for endovascular techniques in trauma but, with this caveat, there are no significant contraindications to the use of IR to arrest haemorrhage in major trauma. There is a growing body of Level 2/3 evidence for its safety, efficacy, speed and cost-effectiveness. There are high costs in establishing and running a 24/7 IR service, but these can result in significant savings compared to alternative surgical treatments.<sup>19</sup>

The decision on whether a patient with traumatic haemorrhage undergoes endovascular treatment, open surgery, a combination of the two or non-operative management (NOM) is typically made by both the trauma team leader and the interventional radiologist after consultation with other consultants involved (Appendix 5). Decisions must be made quickly and should be driven by agreed algorithms. Establishing routes of communication between the services is paramount.

A checklist of quality indicators for IR is provided in Appendix 6.

## 9. Endovascular theatres (see Appendix 6)

When IR is indicated in SIP management, rapid access to endovascular intervention is essential. Therefore, angiography facilities should be located as close as possible to the emergency department and should certainly be in the same building and on the same floor. In future, angiography suites should be co-located within an acute theatre complex/emergency room that provides surgical and anaesthetic support to acutely ill patients. Such facilities are not yet available in the UK.

### Standard 14

IR facilities should be co-located to the emergency department.

## 10. Facilities (see Appendix 6)

Angiography suites must have modern (installed within the last ten years) fixed C-arm imaging equipment. Rooms need to be large enough to handle the numerous individuals who accompany the very unstable trauma patient.

They should have the same facilities as an operating theatre and ideally should have positive pressure air change.

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.<sup>20</sup>

In addition, portable units can only operate for a limited time before overheating.

### Standard 15

Angiographic facilities and endovascular theatres in MTCs should be safe environments for SIPs and should be of theatre standard.

## 11. Protocols

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 CT imaging or embolisation. Agreed pathways and improvements to the local environment should be prioritised to minimise delay while maintaining patient safety.

### Standard 16

Agreed written transfer protocols between the emergency department and imaging/interventional facilities internally or externally must be available.

## 12. Workforce (see Appendix 6)

Adequate staffing levels (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 a consultant-led and delivered IR service.

If resident on-call IR staff are not considered necessary, early warning systems for on-call IR teams should be in place. The priority must be, at all times, to develop systems that reduce the key clinical criterion of the total time to arrest haemorrhage.

### Standard 17

IR trauma teams should be in place within 60 minutes of the patient's admission or 30 minutes of referral.

### 13. Consumable equipment (see Appendix 6)

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 rare occasions when procedures are being undertaken outside the routine angiographic environment.

#### Standard 18

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

Sometimes patients may need to be transferred from one unit to another, for example a TU to an 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).

#### Standard 19

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

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 33–43% of patients, with approximately 15% being defined as major. However, in reviews, only a small proportion of these are followed up.<sup>21–23</sup> Regular multidisciplinary team meetings (MDTMs), as in other services, are required to ensure good communication and holistic management of the patient.

#### Standard 20

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

### 14. Simulation

Simulation of major trauma allows the teams to rehearse unusual as well as more typical scenarios in a controlled manner so that units are better prepared, and should be routinely performed in MTCs and TUs. In 2009 the previous Chief Medical Officer, Sir Liam Donaldson, issued a directive on simulation and there has been a drive to create simulation centres for the purposes of training interventional radiologists for the benefit of patients.<sup>24</sup> MTCs in particular would benefit from access to these.

### 15. 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.

Approved by the Clinical Radiology Faculty Board: 27 February 2015.

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## Appendix 1. Examples of polytrauma protocols

For paediatric trauma patients, refer to the RCR's *Paediatric trauma protocols*.<sup>2</sup>

### Example 1

**The haemodynamically stable SIP:** Clamp urinary catheter before patient leaves emergency department.

**Oral contrast:** Not required for standard protocol.

**Rectal contrast:** When there is penetrating trauma to the abdominal or pelvic cavity, there is a strong argument for using rectal and oral contrast to help detect bowel injury. Give 1,000 ml 2% iodinated contrast delivered via a drip system and ballooned Foley catheter.

**Intravenous contrast:** 150 ml @ 3 ml/sec. Venous access, whenever possible, should be via an antecubital fossa vein. Avoid small peripheral lines on backs of hands, central lines etc. Ideally use a right arm injection and commence scanning at 25 seconds.

**Scan from C6 to groin:** Thorax should be in arterial phase (25 seconds), abdominal and pelvic imaging should then follow, aiming to commence scanning the liver and spleen at 60 to 65 seconds.

**Modify times for the elderly.**

*In order:*

1. Standard head CT
2. Cervical spine

**Collimation:** 1.25 mm

**Coverage:** C0–bottom of T1

Reformats: standard sagittal and coronal

3. Chest, abdomen, pelvis
4. Collimation 2.5 mm. In obese patient or if other technical problems, 5 mm may be a compromise option. Thin slice but noisy images are not helpful.

**Reformats** – reconstruct 2.5 mm sagittal and coronal reformats for dorsal spine and lumbar spine. If suspicion of pelvic trauma, reconstruct pelvic images at 2.5 mm then do coronal reformats. A coronal soft tissue reformat of chest, abdomen and pelvis is often helpful, particularly when discussing findings with clinicians.

**The haemodynamically unstable SIP**

This is aimed at a specific subset of patients where CT forms part of the ATLS primary survey, with the focus of the study aimed at detecting acute life-threatening injuries. This should be used where there is clinical evidence of bleeding or a high likelihood of vascular trauma.

The protocol is particularly aimed at the identification and characterisation of potential bleeding.

Clamp urinary catheter before patient leaves emergency department

**Oral contrast:** Not required.

**Rectal contrast:** Not required.

**Reformats:** As per polytrauma protocol.

1. Standard head CT
2. Cervical spine
  - Collimation: 1.25 mm
  - Coverage: C0–bottom of T1
  - Reformats: standard sagittal and coronal
3. Chest, abdomen, pelvis and extend to knees if possible

Non-contrast-enhanced volume is of no value in trauma.

- a) Arterial phase volume
  - **Intravenous contrast:** 150 ml @ 3 ml/sec. Use a right antecubital vein injection and commence scanning at 25 seconds. Scan from C6 to groin (see thoracic aortic protocols). Modify times for older patients etc.
  - **Collimation:** 1 mm. For obese patient or other technical problems, 2.5–5 mm
- b) Portal venous phase. The abdomen and pelvis should be routinely rescanned in PV phase (not before 60–65 seconds, later for the elderly)
  - **Collimation:** 2.5 seconds. Domes of diaphragm to below symphysis pubis
  - **Reformats** – reconstruct 2.5 mm for dorsal spine and lumbar spine. Sagittal and coronal reformats.
- c) Delayed phase. Abdomen and pelvis 60 seconds post-commencement portal venous phase
  - **Collimation:** 2.5 seconds. The initial images should be reviewed on the scanner console and delayed imaging performed through all areas suspicious for active bleeding or where solid organ injury detected.

## Example 2

### Key points

You are looking for foci of active bleeding and trying to determine whether these are arterial or venous in origin. Active arterial bleeding is rarely self-limiting so urgent treatment is required. Where there is definite active bleeding, this **MUST** be discussed with the on-call interventional radiologist; where the findings are equivocal, the on-call CT consultant. In addition, ensure that the relevant clinician is kept fully informed.

### Patient preparation; refer to the *Paediatric trauma protocols*<sup>2</sup>

- Clamp urinary catheter prior to leaving emergency department (ED) (especially if bladder trauma)
- Oral water unless it delays the scan
- Remove radio-opaque objects
- Patient on a spinal board (ED to do this)
  - Head towards gantry (do not use head rest)
  - Arms by side for head/neck CT and support
  - Arms up if possible for chest/abdomen

### Head – routine head (spiral) in head folder

- Lateral topogram
- 5 mm axial slices over view whole-head recon
- 1 mm axial slices cranium whole-head recon
- 1 mm axial slices bone whole head recon
- 4d recon whole-head angle to lowest border of occiput and supra-orbital margin

### **Neck/chest/abdomen**

- Neck–lat top OR neck/chest/abdo one long ap topogram
- Scan skull base – T4
- Recon thin slice axials bone and soft tissue
- Mprs coronal and sagittal

### **Chest/abdomen/pelvis**

#### **Chest**

- 100 ml contrast 300 @ 3.5 ml/seconds
- Right antecubital vein 19 gauge if possible
- Not through central line or small peripheral lines. (NB There are some central lines that can take 4 ml/second and which can be used if there is no antecubital access. This should be discussed with emergency physicians in planning.)
- 30 second delay
- Lung apices – to top of liver
- Reconstructions: axial 2 mm lung and mediastinum
- 3rd reconstruction: thoracic spine FOV X and Y to be same as lumbar spine

#### **Abdomen/pelvis**

- Top of liver–pubic ramus
- 70 second delay from start of injection
- Reconstructions: axial 2 mm abdo and lung
- 3rd reconstruction: axial 2 mm bone pelvis
- 4th reconstruction: lumbar spine FOV X and Y to be same as t spine

If pelvic/bladder injury is suspected, delays of 2 minutes plus will be needed.

### **Example 3**

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

#### **Biphasic protocol**

- 1) Unenhanced spiral brain 1.25 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/sec then 85 ml at 3.5 ml/sec
  - Scan starts at 60 seconds

This gives both 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/vertebral artery.

- 3) The use of delayed scans limited to specific cases at the request of radiologist.

## Appendix 2. Sample whole-body trauma CT request form

Patient name:		DOB:	
Address:		Sex:	
Consultant:			
<b>Indication</b>			
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 (please specify)			
Current GCS			
Haemodynamically	Stable	Unstable	
<b>Clinical regions of concern</b>			
Head		Abdo pelvis	
C spine		All	
Thorax		None	
Clinical questions to be answered:			
LMP		Catheterised	
Referring doctor		Date	
Signature			

## Appendix 3. 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
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

Clinician contact	Name	Phone/bleep
ED		
Orthopaedic		
General surgery		
Vascular surgery		
Anaesthetic		
Neurosurgery		

## Appendix 4. Secondary trauma report

Date:		Time:
Name:		DOB:
CT head:		
C-spine		Reformats reviewed
T & L spine		Reformats reviewed
Pelvic bones		
Chest		Reformats reviewed
Vascular injury		
Chest wall (ribs)		
Lungs		
Diaphragm		
Mediastinum		
Pleural space		
Other findings		Other structures normal
Abdomen\Pelvis		Reformats reviewed
Free gas		
Bowel/mesentery		
Peritoneal fluid		Haemoperitoneum
Vascular injury		
Spleen		
Liver		
Pancreato-biliary		
Renal/adrenal		
Retroperitoneum		
Bladder		CT cystogram
Other findings		Other structures normal
Delayed imaging		
Rectal contrast		
Conclusion:		
Additional text sheet		Yes/No
Neuroradiology radiology reviewed by:		Copy to neuro room
Musculoskeletal radiology reviewed by:		Faxed to MSK 28241
Body imaging reviewed with:		Copy body CT slot
Reported by:		Faxed to:

## Appendix 5. Guidance on the indications for non-operative management (NOM), interventional radiology (IR) and damage control surgery (DCS) in the SIP

Decisions regarding IR or DCS will be modified according to the facilities and staff available and the patient's stability at presentation<sup>25</sup>

Site	NOM	IR	DCS
Thoracic aorta	No role except in small partial thickness tears	Stent graft for suitable lesions	Ascending aortic injury or arch injury involving great vessels
Abdominal aorta	No role	Occlusion balloon, stent graft for suitable lesions	Injury requiring visceral revascularisation or untreatable by EVAR
Peripheral or branch artery	No role	Occlusion balloon, stent graft or embolisation	Any lesion which cannot rapidly be controlled or which will require other revascularisation
Kidney	Subcapsular or retroperitoneal haematoma without active arterial bleeding	Active arterial bleeding, embolisation or stent graft	Renal injury in association with multiple other bleeding sites or other injuries requiring urgent surgical repair
Spleen	Lacerations, haematoma without active bleeding or evidence of false aneurysm	Active arterial bleeding or false aneurysm  Focal embolisation for focal lesion. Proximal embolisation for diffuse injury	Packing or splenectomy for active bleeding in association with multiple other bleeding sites
Liver	Subcapsular or intraperitoneal haematoma or lacerations without active arterial bleeding	Active arterial bleeding  Focal embolisation if possible  Non-selective embolisation if multiple bleeding sites demonstrated, as long as the portal vein patent.	Packing if emergency laparotomy needed with subsequent repeat CT and embolisation if required
Pelvis	Minor injury with no active bleeding	Focal embolisation for arterial injury (bleeding, false aneurysm or cut-off)	External compression and subsequent fixation if bleeding from veins or bones
Intestine	Focal contusion with no evidence of ischaemia, perforation or haemorrhage	Focal bleeding with no evidence of ischaemia or perforation. Or, to stabilise patient, allowing interval laparotomy pending treatment of other injuries	Ischaemia or perforation requiring laparotomy +/- bowel resection

## Appendix 6. Quality assurance checklist for MTC and TU (unless MTC specified)

Assessing imaging equipment, consumables and staffing	
Imaging*	Y/N
<ul style="list-style-type: none"> <li>Multislice CT scanner in a safe environment, staffed and available 24 hours per day. CT imaging should be available within 15 minutes of a trauma call (MTC and TU)</li> <li>MRI availability 24/7 with written protocols regarding patient movement or, in TUs, written protocols for transfer if required within 12 hours</li> <li>Modern angiography equipment with a C-arm and digital subtraction in a theatre-standard environment (MTC)</li> <li>Contingency plans exist to cover routine service and breakdown</li> </ul>	
<b>Ideal: CT and angiography unit housed within the trauma suite (MTC)</b>	
*equipped with piped gases and anaesthetic equipment as locally specified	
Consumables†	
The following must be available at all times:	
<ul style="list-style-type: none"> <li>Full range of angiographic sheaths, guide catheters, catheters and guidewires including microcatheters and coil pushers (MTC)</li> <li>Full range of embolic agents: coils (including microcoils), vascular plugs, Gelfoam (occasionally glue or PVA) (MTC)</li> <li>Occlusion balloons of various sizes to allow aortic and iliac occlusion (MTC)</li> <li>Stent grafts of various sizes to allow treatment of thoracic aortic injury and peripheral and visceral vascular injury (MTC)</li> </ul>	
<b>Ideal: A trauma box should be maintained with all necessary kit readily available</b>	
†An individual or individuals must be responsible for stock management. Stock levels must be adequate (there needs to be some redundancy), checked regularly and items replaced when levels are low or out of date.	

### Staffing±

The minimum requirement is for the following staff to be available 24/7:

- CT radiographer
- Interventional radiologist capable of embolisation and stent grafting (MTC)
- Angiography radiographer (MTC)
- Angiography nurse (MTC)

### Portering

**Ideal: the angiography team should be mobilised as soon as there is a major trauma call to allow embolisation to start within minutes of diagnosis being established.**

±The on-call rota must be formal, robust, sustainable and sufficiently attractive to allow staff recruitment and retention (MTC).

The TU should have formal arrangements for transfer to an MTC with state of the art teleradiology.

### Protocols

Locally agreed protocols and management pathways should exist for the investigation and treatment of haemorrhage in the SIP. There must be clear delineation of clinical and decision-making responsibility for each stage.

Transfer and resuscitation of patients to and from the imaging department

Transfusion, replacement of blood products and correction of coagulopathy

### Clinical scenarios

Locally agreed strategy for the use of intervention in the management of haemorrhage (or prevention of bleeding) in the following clinical scenarios must be clear.

Pelvic fracture

Solid organ injury

Blunt aortic injury

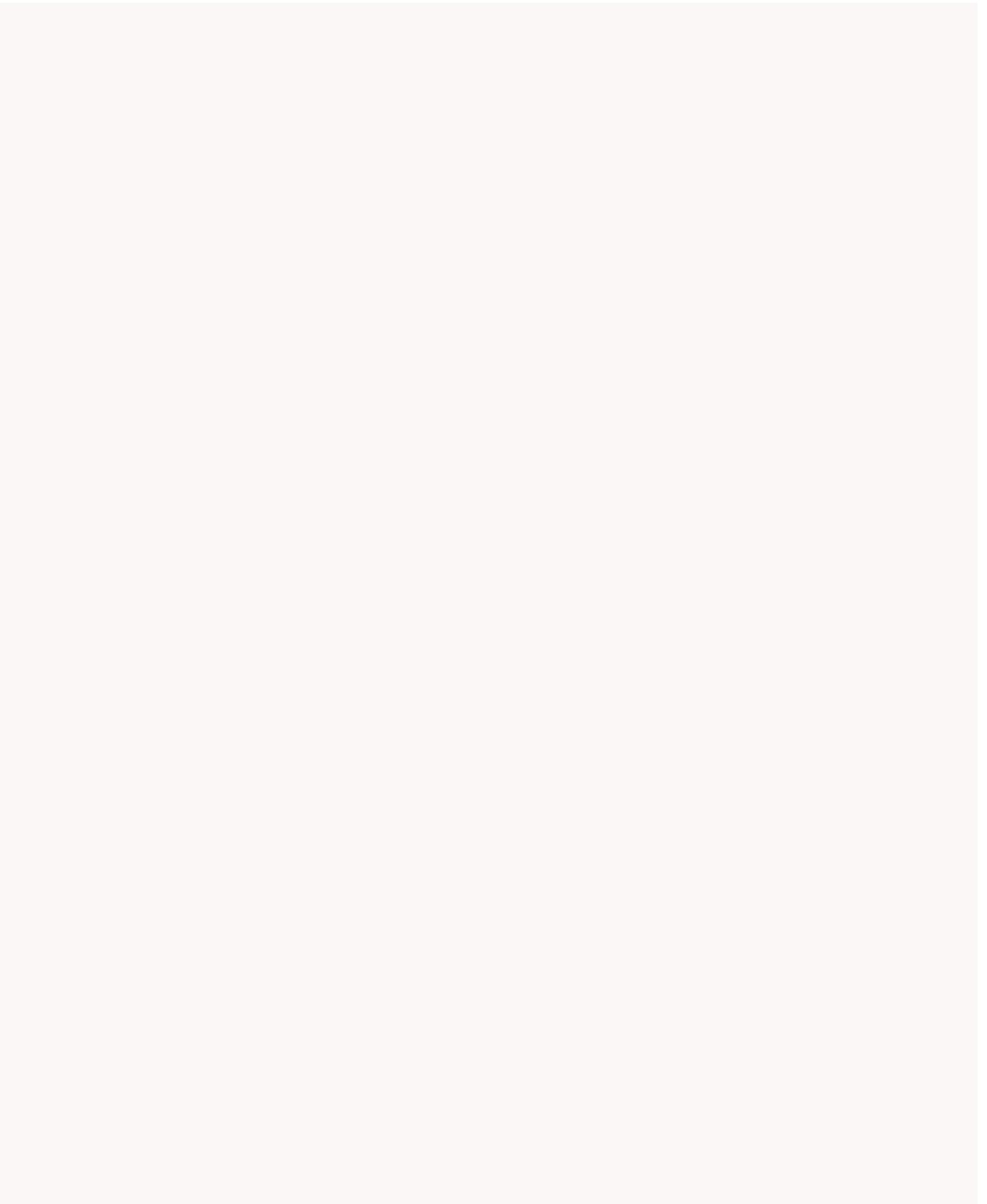
**Audit:** Indication and outcome data should be collected and submitted to national data collection. Audit and benchmarking of performance should be mandatory

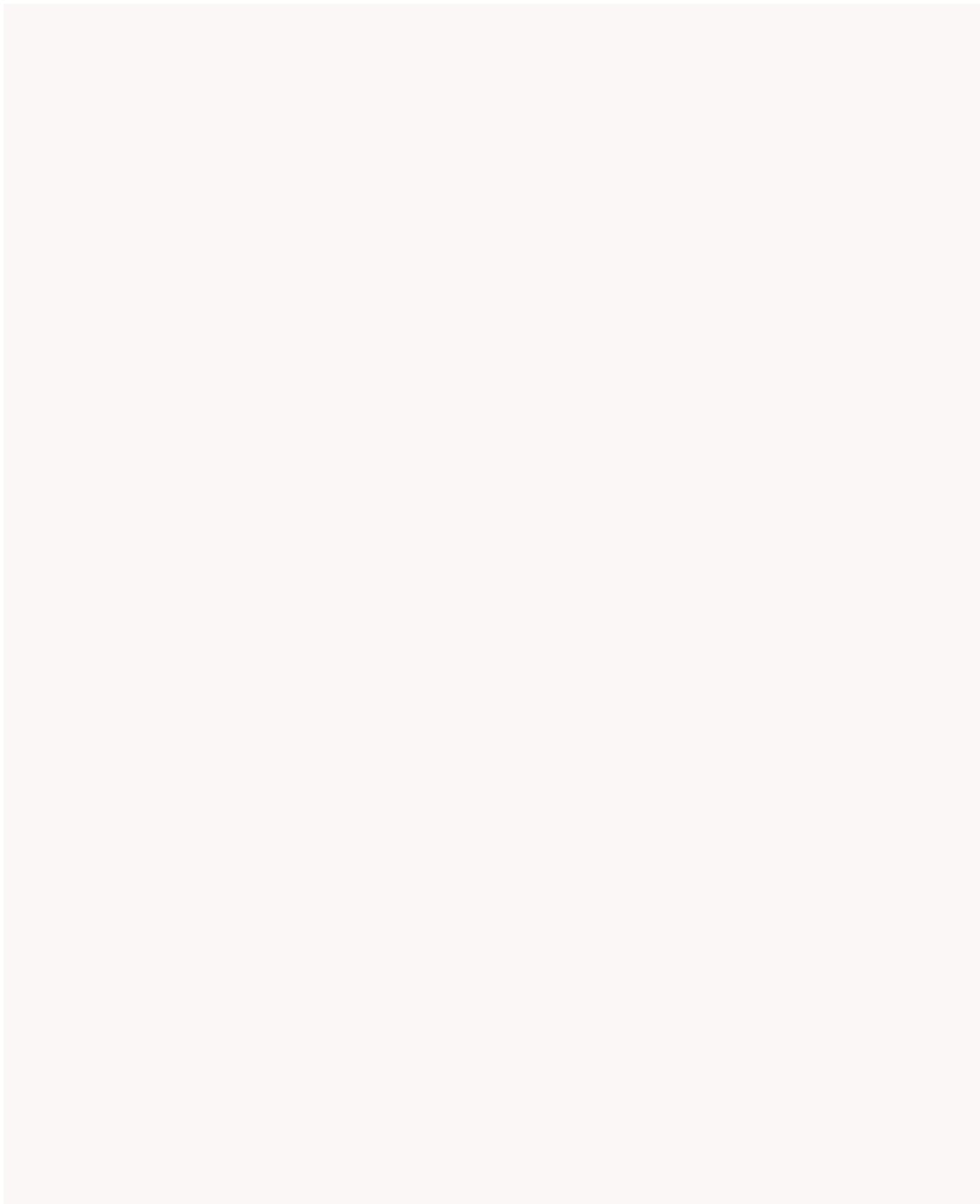
Morbidity and mortality (M&M) meetings and debriefing meetings should be job planned (MTC)

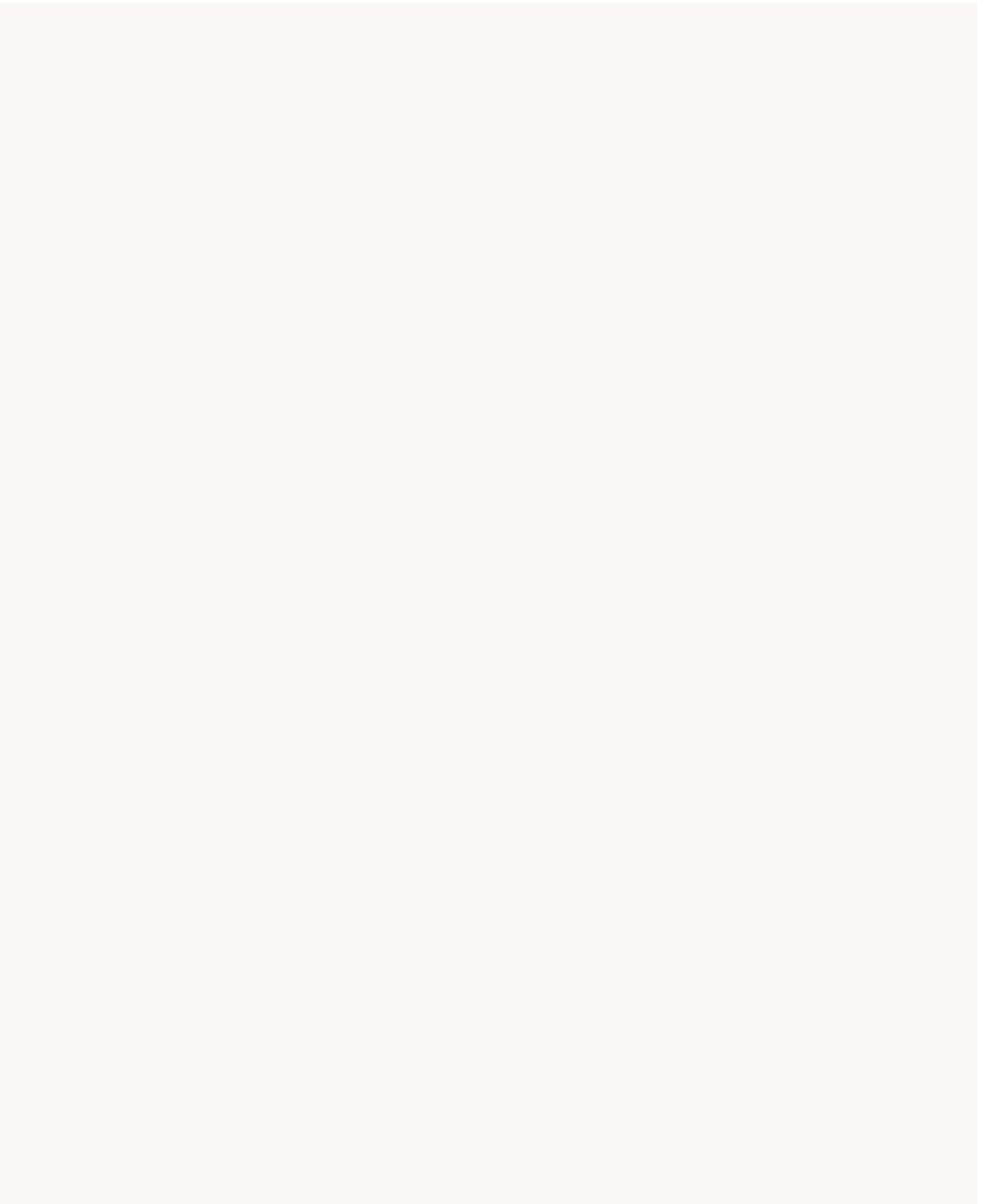
If the answer to any of the above questions is NO, the service is not equipped to manage major trauma. This should be detailed in the hospital risk-management strategy and arrangements to provide suitable alternatives should be made.

## Appendix 7. Glossary

AIS	Abbreviated injury scale
ATLS	Advanced trauma life support
CAG	Clinical advisory groups
DR	Digital radiography
FAST	Focused abdominal sonography in trauma
IEP	Image exchange portal
IR	Interventional radiology
ISS	Injury severity score
MDCT	Multi-detector computed tomography
MTCs	Major trauma centres
RIS	Radiology information system
RCR	The Royal College of Radiologists
SIP	Severely injured patient
TUs	Trauma units







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