British Journal of Anaesthesia **113** (2): 250–7 (2014)
doi:10.1093/bja/aeu203

BJA

Damage control radiology in the severely injured patient: what the anaesthetist needs to know

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Editor's key points

- Multidetector computed tomography is transforming the diagnosis and management of major trauma patients.
- There is increasing evidence to support the use of MDCT in haemodynamically unstable trauma patients.
- Interventional radiology (IR) techniques have become a key component of the management of major injury.
- It is essential that systems are in place for diagnostic and IR trauma centres.

In the treatment of severely injured patients, the term 'damage control radiology' has been used to parallel the modern concept of damage control surgery and the allied development of continuous damage control resuscitation from patient retrieval, through all transfers, to appropriate primary treatment. The aims of damage control radiology are (i) rapid identification of life-threatening injuries including bleeding sites, (ii) identification or exclusion of head or spinal injury, and (iii) prompt and accurate triage of patients to the operating theatre for thoracic, abdominal, or both surgeries or the angiography suite for endovascular haemorrhage control. If we are to achieve these aims, patients must have immediate access to modern multidetector computed tomography (MDCT) which is without doubt the most potent weapon in the diagnostic armamentarium. The most severely injured patients are those who have the most to benefit from early diagnosis and life-saving therapies. The traditional teaching that these patients should go immediately to surgery is challenged by technological developments in MDCT and recent clinical evidence.

Keywords: radiology; radiology, interventional; trauma; X-ray computed tomography

This article provides an overview of how and when to use imaging and interventional radiology (IR) to improve the clinical outcomes in severely injured patients. It will explain why the most critically ill trauma patients potentially have the most to gain from the rapid advances which have taken place in both diagnostic and therapeutic radiology. Anaesthetists already have a vital role in the management of the severely injured patient. We recommend increasing their remit. In addition to life support, anaesthetists have the ability and responsibility to direct patients towards the best pathway of care. This must include ensuring rapid and accurate diagnosis when possible using multidetector computed tomography (MDCT) and considering IR for the minimally invasive control of haemorrhage.[1]

Background

In 2000, the Royal College of Surgeons and the British Orthopaedic Association jointly issued a document 'Better Care for the Severely Injured' recognizing the need for improvements in the care of patients who had sustained major trauma and promoting the development of major trauma networks.[2] The importance of immediate consultant input was recognized, but no mention at all was made of radiology or haematology.

The potential for diagnostic and IR to contribute to the care of patients with major trauma was recognized in the 2007 report by the National Confidential Enquiry into Peri-Operative Deaths (NCEPOD) titled 'Trauma—who cares?' which stated that integration of diagnostic and IR services into trauma care would improve outcomes.[3] Networks of major trauma centres have now been established in England and Wales. Scotland and Northern Ireland are likely to follow. Their aim is to improve care for severely injured patients through the centralization of expertise.[4 5] There is now a need to recognize that many recent publications indicate the pivotal role of diagnostic and therapeutic radiology in the immediate management of severely injured patients. Guidelines and protocols need to continue evolving to reflect this emerging evidence base, in particular recognizing the benefits of prompt MDCT scanning.[6–9]

Why use MDCT imaging in trauma?

The essential reason to use MDCT when possible and appropriate in trauma patients is very simple; MDCT is the quickest and most accurate way to establish the site(s) and extent of injury in order to plan and prioritize management. MDCT is more comprehensive, sensitive, and specific than clinical examination, plain films, or ultrasound in identifying injury.[8]

Table 1 Guidance for the use of urgent whole-body MDCT in trauma. It should be considered urgently for one or more criteria from two separate categories

High-risk mechanism of injury (any one)
RTC with death of passenger
RTC with ejection of casualty
RTC with extrication time >15 min
Pedestrian/cyclist/motorcyclist *vs* vehicle
Fall >2 m or equivalent, e.g. flight of stairs
Anatomical (any one)
Visible injury to >2 body regions (head/neck/chest/abdomen/pelvis/long bones)
Evidence vascular injury (expanding haematoma, laceration over the artery)
Evidence spinal cord injury
Physiological (any one)
GCS<12 or intubated
SAP<90 mm Hg in ED
Pulse <120 beats min^{-1}
Respiratory rate <10 or >30 bpm
Age >65
Anticoagulated patient

In patients whose clinical condition or trauma mechanism suggests severe injury, MDCT is better at identifying life-threatening conditions including intracranial injury, cervical spine fracture, pneumothorax, pericardial tamponade, mediastinal and aortic injury, solid organ laceration, viscus perforation, etc. It is highly sensitive for the detection of ongoing arterial haemorrhage at any site, with negative predictive values for pelvic arterial haemorrhage in the region of 99%.[7–14] Early recognition of these injuries influences management and significantly impacts on short- and long-term morbidity and mortality. Many of these pathologies will be occult on conventional imaging even in expert hands.

MDCT is now the accepted reference standard in trauma imaging. Whole-body scanning (from the head to the knees) can be performed in <90 s with axial images and multiplanar reformats available in <5 min. The rate-limiting steps for CT scanning are now patient transfers to the scanner and on and off the CT table. Several acronyms serve to reinforce this point, for example, FACTT, Focused Assessment with CT for Trauma;[15] FASST, Fast Accurate Sensitive and Specific in Trauma,[9] but unlike their equivalent in ultrasound (FAST, Focused Assessment with Sonography in Trauma), they have not as yet attained widespread clinical usage. In addition, ATLS guidelines[16] arguably lag somewhat behind standard or desired clinical practice where it involves radiological services, and therefore, clinicians may not themselves always be fully aware of what radiology services can contribute or when involvement of radiology services is appropriate.

In severely injured patients who are stable, there is now little argument that MDCT is helpful and should now be the standard of care.[6–8] It is however important that protocols are in place to guide which patients need whole-body MDCT and those where the mechanism of injury, physiological status, or more trivial injury indicates they either do not require CT or only need a scan of a specific body area.[9] A typical protocol is shown in Table 1.

Unstable patients

The NCEPOD report in 2007 stated that 'the philosophy of care that "unstable" patients should not be taken to the CT scanner is widely accepted but not based on any evidence'.[3] It will be shown in this article that the available evidence is that these are in fact the patients who will most benefit from MDCT. Despite this, the contribution of radiology to the management of patients who are deemed unstable or metastable [i.e. maintaining arterial pressure (AP)/achieving permissive hypotension only with ongoing active expert resuscitative support] remains somewhat controversial.

The CT scanner has historically been termed the 'doughnut of death' because of the time involved in acquiring and processing images, delays due to transfer, part-time scanner operation, lack of on-site technical staff availability, and issues relating to prolonged limited access to the patient while in the scanner. Almost all of these factors have been resolved with contemporary scanner technology or can be addressed logistically as discussed later in this article. Unfortunately, recent ATLS guidelines promulgated in teaching courses continue to assert that 'CT is a time-consuming procedure that should be used only in patients with no haemodynamic abnormalities'[16] and the standard dogma remains, that 'unstable patients' should bypass MDCT altogether and go straight to the operating theatre, even in the most recent of literature.[1]

In fact, it can be argued that the sickest patients are those who are most likely to benefit from MDCT. This is due to its comprehensive survey and its sensitivity and specificity in identification of life-threatening injury. Clear evidence is emerging to support this position. The term 'damage control radiology'[17] has been coined to parallel the concept of damage control (rather than reconstructive) surgery, and the overall concept of continuing damage control resuscitation from patient retrieval, through all transfers, to appropriate primary treatment.[18] The aims of damage control radiology are (i) rapid identification of life-threatening injuries including bleeding sites, (ii) identification or exclusion of head or spinal injury, and (iii) prompt and accurate triage of patients to the operating theatre for thoracic, abdominal, or both surgeries or the angiography suite for endovascular haemorrhage control.

In the majority of these patients, haemodynamic instability is due to ongoing haemorrhage and the critical time that influences patient survival is the time to achieving haemostasis and normalization of physiology. If the use of MDCT can shorten this overall period, it will have an impact on patient survival.

Limitations of traditional imaging in unstable patients

Traditional and widely used imaging in such patients has been a standard plain film series and ultrasound (FAST). Although

these can certainly provide useful information, they also have significant limitations that are not always sufficiently recognized by clinicians in the trauma environment.

Plain radiograph series

The standard ATLS plain radiograph trauma series (AP chest, lateral cervical spine, and AP pelvis) is commonly acquired rapidly and gives some rapid useful information. However, up to 76% of pneumothoraces and other significant chest complications identifiable on MDCT are occult on the chest radiograph.[19] Lateral cervical spine radiograph sensitivity for injury is 52% compared with near 100% on MDCT.[20] Even in obtunded patients, a normal MDCT examination of the neck by an appropriately experienced radiologist is sufficiently sensitive to allow early removal of a hard collar with some simplification of ongoing management and vascular access.[21] A pelvic binder should be placed on all patients with appropriate thresholds of injury. A pelvic radiograph can be performed afterwards, but again is not as sensitive as MDCT. Formal external pelvic fixation does not preclude MDCT examination.

Plain film examinations can be extremely helpful, but performing them must not be allowed to delay MDCT examination if it is possible to proceed to it.

Focused assessment with sonography in trauma

The use of ultrasound as a screening tool in trauma patients, mainly to identify free intra-abdominal fluid, has been established practice in many institutions for many years. More recently, it has been used as an extended examination to the pericardium and chest. FAST is widely advocated as a useful technique. It is mentioned in ATLS guidelines[15] and there is a considerable industry behind the technique in training courses for relevant physicians looking after these sick patients.

Essentially, the presence of free intraperitoneal fluid in an unstable patient is said to mandate transfer to theatre without further imaging. Certainly, such transfer is entirely appropriate in some patients to achieve rapid haemostatic control. However, on more rigorous examination, the role of FAST in selecting such patients has been questioned. Many of the quoted results for sensitivity and specificity refer to series with heterogeneous populations comprising a majority of stable patients with far fewer unstable patients. If the unstable groups are looked at in isolation, FAST performs poorly even in experienced hands. One study reported a negative predictive value of 50% (i.e. equal to tossing a coin) in the identification of free intraperitoneal fluid subsequently identified at surgery, and other studies confirm a significant false-negative rate.[22–25]

Stable patients will get MDCT anyway if appropriate, so the need for FAST in such patients is questionable other than allowing clinicians to practice. Conversely, in a multiple casualty scenario, the additional information gained by FAST may assist in triage, even if the examination is imperfect.[17] If used, FAST must not delay transfer to MDCT or theatre and given its clear limitations, it should be used more to gain additional information than be a major and unappraised basis for case triage.

Evidence for and issues in the use of whole-body MDCT in unstable patients

MDCT is more comprehensive than plain films or ultrasound, and more reliably identifies important treatable injuries and ongoing haemorrhage. If MDCT can be performed promptly, then theoretically some or all of the other investigations can be omitted. Rapid transfer to CT is the preferred pathway recommended in UK guidelines.[8] The decision to use MDCT should be based on the patient's physiological condition and mechanism and degree of injury. The performance of other imaging should neither delay definitive imaging (MDCT) nor be used alone to select which patients should be scanned.

The main issue in using MDCT in severely ill trauma patients is concern that its use will introduce unacceptable delay which adversely impacts patient outcome. However, as recognized in the 2007 NCEPOD report, there is no evidence for routinely omitting MDCT in unstable trauma patients.[3] The available evidence shows that it is precisely this patient group who will gain the most from MDCT imaging before intervention.

A review of 10 000 patients showed the majority of blunt trauma deaths were due to head injury, requiring its rapid identification in consequent triage.[26] A further study of 4621 patients showed the use of whole-body MDCT is a significant predictor of patient survival, even after adjustment for confounding factors and injury grade, and 16% of patients scanned in this series were unstable (SAP$<$90 mm Hg).[27] A further recent study showed the use of MDCT before emergency bleeding control was associated with a survival benefit only in the most unstable patients.[28] The reason for such benefit is presumably that the scan directs treatment immediately to the life-threatening injury. Immediate (during primary resuscitation) MDCT is performed in several European departments. Trials to assess this approach are underway and should report in the near future.[29]

Haemodynamic instability should therefore be viewed as a reason to scan a patient as soon as possible. Traditional pathways advocating the assumed immediate transfer of all unstable patients to the operating theatre without considering the use of MDCT are outdated. Laparotomy itself has its difficulties with diagnosis and treatment of bleeding sites, particularly in the retroperitoneum or pelvis. Surgery may also promote haemorrhage by disrupting tamponade as seen in ruptured abdominal aortic aneurysm.

Location of MDCT in the emergency department (ED) is advocated as this will simplify logistics and maximize the proportion of patients who will benefit.[8] However, this may sometimes be difficult to achieve in the current economic climate and competing imaging requirements. While intuitively this seems to be the best arrangement, there is no clear evidence of benefit to date. The Dutch REACT 1 randomized trial of 1124 patients showed that although a CT scanner located in ED rather than elsewhere reduced the time to perform MDCT (from 49 to 36 min), there were no substantial improvements in clinical outcomes in a general trauma population. A trend towards beneficial outcomes in the more severely

injured patients scanned in the ED did not reach statistical significance.[30]

A common observation is that the delay in transferring relatively unstable patients to radiology services in well-rehearsed situations can be much smaller than the cumulative delay incurred in the resuscitation room. The REACT 1 trial confirms this, showing that even when the CT is in the ED, there is still a mean interval of 36 min between arrival and starting scanning. In practice, almost all haemodynamically unstable patients who survive their injuries will have their life-saving procedures performed somewhere other than the resuscitation room. Protocols should therefore focus on three phases of management: (i) immediate stabilization in the ED followed by (ii) diagnosis (MDCT) and then (iii) targeted treatment. In reality, diagnosis and therapy will usually involve transfer from the ED. Procedures and transfer protocols should be developed, and just as importantly rehearsed, to minimize any delays inherent in transfer and increase the proportion of patients getting the benefit of MDCT.[8] Damage control resuscitation should continue during the whole process. The role of the anaesthetist is most critical in this phase. Facilities for continuing resuscitation and managing untoward technical events must be available and where required, transported to and maintained in the MDCT environment.

In order to increase the proportion of patients being imaged and benefiting from targeted surgery or IR techniques, protocols in the resuscitation area need to be continuously and critically appraised. In particular, care must be taken to avoid delays resulting from the involvement of multiple specialities too early in the patient pathway. Anaesthetists themselves must consider the potential delay in achieving haemostasis if their initial attempts to optimize monitoring are not promptly successful.

Diagnostic imaging services are only of use in the most severely injured patients if MDCT is available immediately once the decision to image has been made. The operational logistics to deliver this may vary from centre to centre. If resident staffing is not available, then procedures should be put in place to call out relevant staff (including consultant radiologists). Trauma call out may occur before the patient has arrived in the hospital and before the need for their involvement has been determined. The call out decision will be based on prehospital assessment much as in Table 1. It is better for a radiology team to stand down and not be needed than not to be there when immediately required. Although Royal College of Radiologists guidance[8] is that a senior radiology trainee can be the first reporter, and a consultant available afterwards or online within an hour, it is the view of the authors that at least with the most severely injured patients, an actual radiology consultant presence is very helpful in interactions with the trauma team and minimizes delay. This was also the view of the UK military during the Afghanistan conflict and led to radiologist deployment.[17] A recent survey of UK EDs suggests in fact many radiology departments are near to achieving this.[31]

The exact MDCT protocol used is probably less important than the ability to perform a standardized examination rapidly in these ill patients. A non-contrast head to assess for intracranial haemorrhage, followed by a dual-phase contrast injection for the neck and trunk, will identify injuries requiring the most immediate management including the site of any ongoing bleeding or solid organ laceration.[8 17] The same scan can be extended to the lower legs to provide angiographic imaging if there is lower limb injury.[32] Unstable patients can usually be taken off the scan table immediately after scan acquisition if a radiologist is present.

Reporting of the MDCT should be structured and initial communication should be with the designated trauma team leader. Repeated interruptions by multiple specialities each requesting information relating to their speciality must be avoided as these are intensely distracting to the reporting radiologist. Crowd control in the vicinity of the scanner is important for the same reasons. The team should be limited to those directly involved in resuscitation or planning immediate management, particularly the lead trauma clinician. When reporting, an initial survey should identify immediately life-threatening findings (akin to an ATLS primary survey) that can be communicated to the trauma team to assist in patient stabilization. Significant head injury can rapidly inform whether additional intervention in the trunk is futile. A secondary survey should then be performed for the whole scan and any additional findings communicated, including radiological clearance of the cervical spine. The patient may already have been transferred to theatre or the angiography suite by the time that this report is available. Given the large number of images and information acquired, a further review remote in time can identify further abnormalities or corrections; usually, these additional findings do not mandate immediate intervention.[33 34]

Interventional radiology

Most preventable deaths in trauma patients are due to ongoing haemorrhage, either in the short-term from exsanguination or hypotension or in the next few days and weeks from multiorgan failure. Identifying ongoing haemorrhage and achieving haemostasis as rapidly as possible is central to improving outcomes in major trauma. Minimally invasive IR techniques to stop active bleeding have been available for decades and have become widely used in other unstable bleeding populations, for example, gastrointestinal and post-partum haemorrhage, and endovascular aneurysm repair.

In the damage control context, three different interventional techniques are used to control bleeding: temporary balloon arterial occlusion, embolization to occlude arteries, and stent grafting to repair injured vessels. IR also has a role in the longer-term management of the severely injured patient, but this is beyond the scope of this article.

IR and surgery are complementary interventions. In these patient groups, the patient's unstable condition should not preclude transfer to radiology. Interventional radiological techniques such as placement of an occlusion balloon, embolization, or stent grafting (Fig. 1) can arrest haemorrhage rapidly and can be life-saving.[7–10 35]

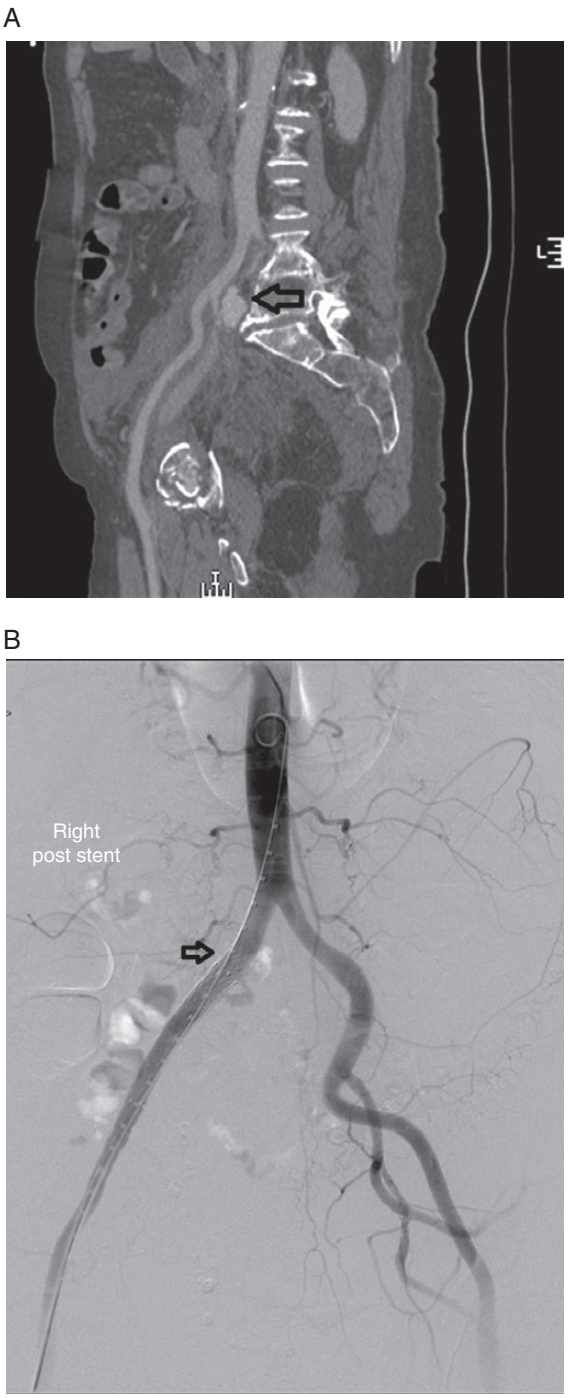

Fig 1 A 75-yr-old female pedestrian injured in road traffic collision. Permissive hypotension but unstable. (A) Sagittal reformat of MDCT showing ruptured internal iliac artery at its origin form common iliac artery (arrowed). Extensive pelvic haematoma and fractures. (B) Stent-graft placement (arrowed) lining iliac artery with immediate AP restoration. Time from ED to CT 45 min. Time from the patient coming off CT table to completion of stent-graft 15 min. In retrospect, balloon occlusion of the aorta or iliac artery while in CT could have been considered. Interval cholecystectomy at 14 days for presumptively ischaemic perforation. Patient died at 30 days from multi-organ failure.

MDCT examination rapidly identifies the site of ongoing haemorrhage and will help clinical teams determine whether physiological haemostasis will be best and most rapidly achieved by embolization or surgery or a combination of the techniques. IR should be conceptualized as an arm of damage control surgery and not as non-operative or 'conservative' management. In experienced hands, MDCT will allow clinicians to estimate how long it will take to achieve haemostasis by IR techniques. This is important in the elderly atherosclerotic population where access to bleeding sites may be more difficult or time-consuming. Additionally, surgery may be preferable in the presence of multiple significant bleeding sites in the abdomen. Although each site may be controllable by IR, the surgical approach will be far faster. The patient's ongoing condition while in MDCT will be relevant to any discussion and the anaesthetist's role is critical in such a discussion.

One possible limitation of MDCT in unstable patients is a false-negative result if there is no extravasation during the scan period. This may occur if there is a temporary loss of AP control, with bleeding starting again once permissive hypotension is achieved. It is however likely that MDCT will show a likely site of recent bleeding, whether in the mediastinum, retroperitoneum, or abdomen to guide priorities for subsequent surgery.

Most stable patients will have MDCT if appropriate and decisions about onward management in IR and DCS can be carefully considered. However, it is almost never indicated to proceed to IR without MDCT in less stable patients. Older literature advocating this refers to a time when CT examination took much longer than it does now, or was not even available and angiography was used for diagnosis rather than therapy. Identification of the site of bleeding at MDCT can decrease the overall time to haemostasis, even if the commencement of the required intervention (DCS or IR) is a little delayed (Fig. 2).

Most embolic agents such as coils, plugs, or gelfoam are intensely thrombogenic. However, they require that some of the clotting cascade is active, and therefore, active expert haematological support to minimize coagulopathy is essential. The importance of haemostatic and damage control resuscitation taking place from patient retrieval all the way through to transfer to radiology cannot be overstated if subsequent IR treatment is to have any chance of success. It is however possible to use cyanoacrylate glue to stop bleeding if required. Glue is less dependent on the patient's clotting status, but this technique is associated with additional technical challenges and is not always ideally suited to the emergency environment.

Evidence for the use of IR in traumatic haemorrhage

The best trial evidence for IR techniques is in the transected thoracic aorta where stent grafting is a better technique than surgery with regard to patient survival and complications.[36 37] However, interventional radiological techniques, primarily embolization, are increasingly used for abdominal bleeding and much lower level evidence supports its use with little contradictory evidence. IR comes into its own where surgery is particularly difficult or may be unsuccessful, particularly in pelvic or retro-peritoneal haemorrhage but can be used

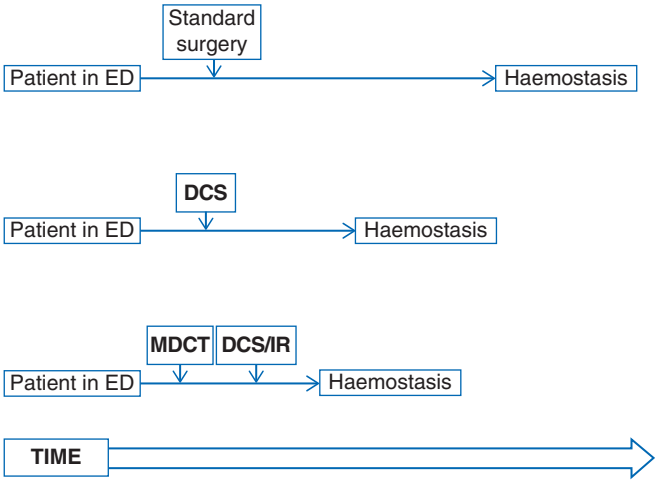

Fig 2 Diagram to conceptualize the benefit of damage control surgery (DCS) over standard surgery in obtaining earlier haemostasis. The use of MDCT can shorten this overall time as it will guide DCS (or IR) to achieve directed haemostasis more quickly, even if the start of the therapeutic manoeuvre is slightly later than it might otherwise be.

for other areas.[7–9 35 38 39] It has an increasingly important place in splenic conservation in this often young patient group (Fig. 3) and is widely used in other solid organ injury.[38] Like any intervention, IR techniques have their own complications, but these are sometimes difficult to disentangle from the effects of the primary injury.

Owing to the heterogeneity of the trauma population and clinical teams, the decision-making process between IR and DCS for haemorrhage control will sometimes depend on the relevant expertise of the particular clinicians involved on any given day. This should be recognized and decisions taken jointly. The priority is to normalize physiology as far and as quickly as possible with the minimization of intervention-related complications. The anaesthetist must be involved in these discussions as they will have to manage patients in the respective environments and the associated transfers.

Similar to MDCT, IR should be available immediately when required rather than be requested if needed and the same processes for calling out IR teams should be considered as previously described for MDCT. This will increase the proportion of patients for which these treatments can be considered.

Balloon occlusion

The use of balloon aortic occlusion as an alternative to aortic clamping or thoracotomy to achieve temporary immediate haemorrhage control is at first sight an attractive technique and has been used successfully for many years by interventional radiologists in post-partum haemorrhage and ruptured aortic aneurysm and trauma.[9] Prolonged inflations do have a subsequent metabolic cost, as does delay in achieving haemostasis. The difficulties in introducing catheters into collapsed femoral vessels perhaps below a pelvic binder *in situ*, in hypotensive patients, even with ultrasound guidance in expert hands, can be under-estimated by inexperienced practitioners (Fig. 4). Attempts at balloon occlusion also have the potential to further delay definitive treatment. Trials are proposed to look at whether this is a useful procedure in the trauma armamentarium while the patient is in the ED (REBOA—Resuscitative Endovascular Balloon Occlusion of the Aorta), and results of these will be of major interest. However, surgical control of the aorta or both common iliac arteries can be performed rapidly by experienced trauma surgeons, and particularly in military practice, patients have been returned to MDCT after this immediate temporizing control has been achieved.[16] It should be remembered that balloon occlusion and arterial clamping will obscure distal haemorrhage unless released during MDCT, and may require temporary release to allow contralateral femoral access for embolization.

Conclusion/learning points

The aims of damage control radiology are (i) rapid identification of life-threatening injuries including bleeding sites, (ii) identification or exclusion of head or spinal injury, and (iii) prompt and accurate triage of patients to the operating theatre for thoracic, abdominal, or both surgeries or the angiography suite for endovascular haemorrhage control. MDCT achieves all of these aims.

Agreed algorithms need to be in place so that MDCT is not overused in the much larger group of patients with more trivial injury and no physiological upset.

A clear body of evidence is emerging that it is possible and beneficial to manage unstable patients through MDCT with a proportion of these being appropriate for haemostatic control achieved by IR techniques rather than damage control surgery. The decisions about whether, how, and when to transfer for imaging, and whether to use IR or surgery or a

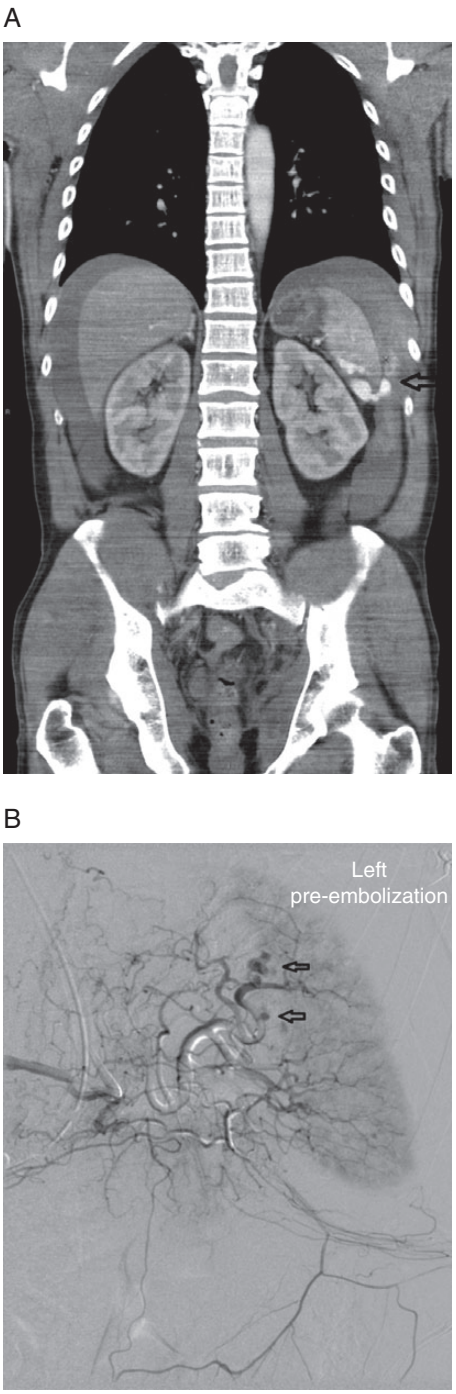

Fig 3 A 40-yr-old male injured in road traffic collision. Permissive hypotension but unstable. (A) Coronal CT reformat shows splenic contusion, active extravasation from the spleen (arrowed), and free intraperitoneal blood. (B) Pre-embolization image at angiography. The patient had splenic artery embolization to area of vascular injury (arrowed) with immediate AP restoration. Time from ED to CT 60 min. Time from coming off CT table to last splenic artery coil 15 min. Temporary ileus in hospital. Patient discharged well at 14 days. If procedure had not been as straightforward, a more proximal splenic artery embolization could have been performed.

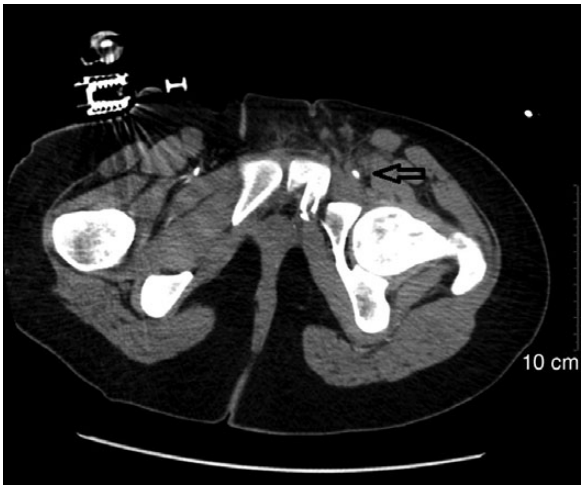

Fig 4 A 22-yr-old female injured in road traffic collision. Extensive pelvic injury, metabolic upset, and coagulopathy on delayed arrival. Extensive pelvic haematoma with no bleeding site identified, presumably due to transient loss of blood pressure control. Note size of femoral arteries (arrowed) below pelvic binder which might render access difficult even with ultrasound control. Time from ED to CT 25 min. CT also showed irretrievable head injury and resuscitation was abandoned.

combination for haemostatic control are complex in this heterogeneous population and can only be made by discussion between senior clinicians present on site.

The utility of MDCT in severely injured patients suggests that it should be used by default, and only bypassed when there are cogent clinical reasons for so doing. The existing evidence in fact implies a survival benefit by its use in the most unwell patients. Protocols should be put in place and rehearsed, so the maximum number of critically ill trauma patients can benefit from MDCT examination whether this is located in the ED or not. Anaesthetists have a pivotal role in the design of such arrangements and the associated transfers.

Declaration of interest

None declared.

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Handling editor: S. J. Howell