



## Pictorial Review

# Bomb blast imaging: bringing order to chaos

E.A. Dick<sup>a,\*</sup>, M. Ballard<sup>b</sup>, H. Alwan-Walker<sup>c</sup>, E. Kashef<sup>a</sup>, N. Batrick<sup>d</sup>,  
S. Hettiaratchy<sup>e</sup>, C.G. Moran<sup>f</sup>

<sup>a</sup> Department of Radiology, Imperial College Healthcare Trust, St Mary's Hospital, Praed St, London W2 1NY, UK

<sup>b</sup> Department of Radiology, University Hospitals Birmingham, UK

<sup>c</sup> Department of Radiology, University Hospitals Manchester, UK

<sup>d</sup> North West London Trauma Network, Imperial College Healthcare Trust, St Mary's Hospital, Praed St, London W2 1NY, UK

<sup>e</sup> Department of Surgery, Imperial College Healthcare NHS London, UK

<sup>f</sup> National Clinical Director for Trauma, NHS-England, Skipton House, London, UK



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Blast injuries are complex, severe, and outside of our everyday clinical practice, but every radiologist needs to understand them. By their nature, bomb blasts are unpredictable and affect multiple victims, yet require an immediate, coordinated, and whole-hearted response from all members of the clinical team, including all radiology staff. This article will help you gain the requisite expertise in blast imaging including recognising primary, secondary, and tertiary blast injuries. It will also help you understand the fundamental role that imaging plays during mass casualty attacks and how to avoid radiology becoming a bottleneck to the forward flow of severely injured patients as they are triaged and treated.

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## Introduction

Blast injuries are complex, severe, and outside of our everyday clinical practice, but every radiologist needs to understand them. By their nature, bomb blasts are unpredictable and affect multiple victims, yet require an immediate, coordinated, and whole-hearted response from all members of the clinical team, including all radiology staff. This article will help you gain the requisite expertise in blast imaging. Ideally all radiologists should read this article ahead of time and bookmark it, so that when a bomb blast occurs, they are able to respond quickly and effectively, giving the victims the best chance of surviving and returning to their lives.

## Principles and preparation for a bomb blast major incident

Radiologists have a crucial role in preparing for major incident or mass casualty events as radiology is a major step along the pathway between the emergency department and theatre for many blast patients. It is imperative that imaging does not become a bottleneck to the flow of patients, so they should receive “rapid but abbreviated care”.<sup>1,2</sup> To maximize clinical preparedness, all staff need to understand different forms of traumatic injury and have knowledge of the workload expected, which is inevitably a challenge.<sup>3</sup>

### Pre-hospital

Terrorist bombs result in multiple casualties over a short period of time and can overwhelm even experienced and prepared hospitals. Moreover, a high proportion of patients have critical injuries: in the Madrid attacks of 2004, 43% of

\* Guarantor and correspondent: E. A. Dick, Department of Radiology, Imperial College Healthcare Trust, St Mary's Hospital, Praed St, London W2 1NY, UK. Tel.: +44 02033121116.

E-mail address: [Elizabeth.dick1@nhs.net](mailto:Elizabeth.dick1@nhs.net) (E.A. Dick).

patients had severe or life-threatening injuries and >30 patients underwent one computed tomography (CT) examination in 3 hours at one hospital.<sup>4</sup> Therefore the process of pre- and in-hospital triage needs to be optimised to promptly identify and treat these critically ill patients, avoiding both over-triage (i.e., overwhelming hospitals with non-critical patients) and under-triage (missing critical injuries).<sup>5,6</sup> In a major incident the most severely injured will be conveyed to the major trauma centre with less severely injured being treated in network trauma units; however, in the event of a mass casualty incident, it is likely that priority 1 casualties (most severely injured) will be distributed more widely with trauma units needing to manage complex injuries as well.

### *Hospital preparation*

As a clinician, it is important that you know your role during a major incident. Remember that the hospital will be in security lockdown if there has been a terrorist attack; you must bring your identity card, should know your safe hospital entry point, and know where to report in advance. As soon as a major incident is declared, appropriate (and pre-designated) areas in the hospital, including the radiology department, should be cleared of all elective and non-urgent patients. A robust system to re-book patients including clear information for the patients themselves should be part of any major incident plan. This should ensure that their care is not disadvantaged in the long term, but that mass casualty and urgent/seriously unwell non-mass casualty patients are prioritised in the short term. Blast victims require more intensive clinical care than usual trauma patients, therefore, resources must be focused on these patients to minimise in-hospital mortality.<sup>7</sup>

Information about the number of casualties and type of injury will be sparse, inaccurate, and changeable. Therefore, until the major incident is stepped-down, the major incident plan needs to stay flexible, using all resources available. One recent example is the use of encrypted messaging applications for instant communication of decisions and plans to all staff (without sharing patient-specific data).<sup>8,9</sup>

Clinical and non-clinical staff must be called in and allocated to key areas of the emergency and radiology departments. Radiologists are among the specialists needed most,<sup>3</sup> so the number of staff present for the initial wave should be carefully calibrated. Crucially, planning for staff for a second and third wave, roughly 8 hours and 16 hours post-event, should start early, as this wave of care is just as important as the initial wave. Emphasising the value of the second and third wave staff is vital to avoid staffing imbalances, and it is important that staff designated to the second and third role have a key role to play.<sup>9,10</sup>

Radiologists need to be stationed in the emergency department to provide FAST (focused abdominal sonography for trauma) and immediate plain film reports (minimum of two radiologists in the emergency department).<sup>11</sup> Further radiologists at each CT workstation provide a hot report on each patient: experience from the recent terrorist attacks in London and Manchester suggests that two radiologists per CT system allows efficient patient throughput

and rapid reporting. It is likely that more than one CT system and more than one interventional suite will be running during a major incident, requiring sufficient staff of all disciplines, including porters, for optimal rapid patient flow. Close co-ordination between radiologists in the emergency department, CT room, and the interventional suite is required with a designated senior radiology lead in each of those areas, each communicating with each other. We recommend that all personnel stick to their normal roles as much as possible, for example a consultant neuroradiologist should not be deployed for FAST, but could be stationed in CT to act as the second reader for all CT examinations of the head.

### *General principles of imaging*

All critical patients require chest, pelvis, and extremity plain films depending on the site of injury. Radiography is considered the best imaging technique for initial rapid assessment of fractures and penetrating trauma in particular. Familiarity with plain film appearances is an advantage, especially as, unlike current practice, CT will be used more sparingly at first.<sup>12</sup>

As for all major trauma patients, unstable critically ill patients are usually transferred straight to theatre from the emergency department with only a FAST scan or plain radiography. Stable critically ill patients proceed to CT for a standard-protocol contrast-enhanced whole-body CT: there is no place for selective CT in a major incident.<sup>9</sup> The CT should cover the entire body from head to pelvis (+/- CT angiogram of limbs) and include a scout view, which is particularly helpful in identifying shrapnel.<sup>13</sup>

Non-critical casualties often need radiographs (up to 70%<sup>2</sup>), but radiological resources should be actively managed to avoid focusing attention on these patients, who can block the forward flow of critically ill patients. Non-critical patients form the majority of victims and may arrive in hospital ahead of critically ill patients who need extrication and conveyance from the scene. Ideally non-critical patients should be triaged (and re-triaged as a small number will have occult critical injuries) at a temporary casualty centre out of the hospital.<sup>7</sup>

During the initial phase, as casualties continue to arrive at the hospital, major diagnostic tools, such as CT and angiography, should be used relatively sparingly; when the “plateau/definitive” phase is reached, optimal care can be provided and the patients reassessed. In the final “step-down” phase awareness of complications and re-triage should be maintained.

### *Questions to ask before and during the radiologist's report*

Although information may be inadequate initially, key points to evaluate from media outlets at the time of the initial major incident call should include: (1) was the blast in an open or closed environment? In open air, the blast wave dissipates in inverse proportion to the cubed distance from the centre; however in a closed environment, such as a

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