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A Guide to Mass Casualty Incidents for Radiology Residents: Strategies, Ethics, Directions

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A B S T R A C T

Mass casualty incidents, by nature of their scale and unpredictability, can rapidly overwhelm health infrastructure. Preparation is the key to managing these crises with the lowest risk to emergency and health personnel, while providing maximal life saving measures. We present an overview of the multitiered planning that should go into forming a well set out emergency response plan and one that is capable of being adapted to a wide range of mass casualty scenarios. We highlight the ethical implications that a healthcare team faces while making challenging decisions rapidly in a high-pressure environment. Radiology trainees should be aware of the response systems in place at their institutions and the role that is expected of them in mass casualty incidents.

Introduction

The COVID-19 pandemic has given the medical community a real-life practical opportunity to study and reform approaches to mass casualty incidents (MCIs), emphasizing the importance of effective policies, planning and preparation. Besides the recent pandemic caused by SARS-CoV2, the number of MCIs worldwide are increasing.[1,2] Awareness of basic MCI principles and their execution should be introduced, studied, and applied during medical school and residency.

This review aims to shed light on different aspects of MCI so that medical students and radiology residents may play an effective role in disaster management even as trainees and to provide them with the knowledge and know-how to help to shape future policies. Motivated by the rising rates of MCI, we present a step by step approach to MCI, addressing the policy, planning, ethics, simulation and execution while highlighting the role of radiology in MCI.

What Is a Mass Casualty Incident?

An MCI is a situation when the number of patients requiring hospital care exceeds the immediately available structural and technological resources.[3] According to the WHO, any incident where the number of victims disrupts the normal functioning of health care provision and emergency care can be categorized as an MCI[4]; the threshold is unique to the individual healthcare setting and there is no set number for this definition.

The standard of care in an MCI is to assess and treat the largest number of victims possible in order to minimize morbidity and mortality. MCIs change both the workflow dynamics in a health care system and the immediate standard of care of all patients at an institution, not just those involved in the MCI. The threshold of care shifts from the best possible care for a single patient to the minimum acceptable care for the maximum number of patients.[5]

MCIs can be categorized based on causation into 2 main categories: natural and man-made. Man-made MCIs can be subclassified into intentional and unintentional (Fig 1).[6] Examples of natural catastrophes include pandemics, earthquakes, and hurricanes. Manmade MCIs include mass shooting, acts of terrorism, and riots; while unintentional manmade MCIs include transportation accidents involving large numbers of passengers or structural collapse. Detailed information about the cause and mechanism can help predict the types of expected injuries.

Some medical pandemics, and natural disasters like tsunamis or earthquakes, can be predicted to some extent in the short term, while most MCIs cannot be predicted, therefore health care systems have to be proactive in developing plans to manage various MCI.

During an MCI, numerous skilled prehospital and hospital personnel are activated. Prehospital care includes provision of basic life support at the scene of an MCI with triage and notification to the receiving facilities. Triage involves categorizing the patients into groups to guide future management; early triage is initially performed by first responders including paramedics, military, police, and fire departments. Victims are categorized with the help of color coding—usually in the form of bands, tags or some other markers. Red markers signify patients who require urgent immediate lifesaving intervention. Yellow markers denote an intermediate category

Abbreviations: MCI, Mass casualty incident; RCC, Regional command center; DMP, Disaster Management Plan; DCC, Disaster command committee; EMS, Emergency Medical Services

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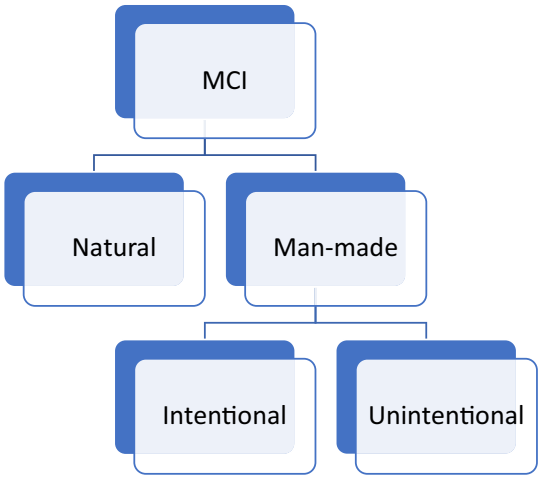

FIG 1. Classification of MCI based on the causation.

requiring intervention in 2-4 hours. Green markers denote patients who are stable but still require medical attention. Dead or victims unlikely to survive are marked with black markers.

Triage is dynamic in an MCI setting, categorized into primary, secondary and tertiary triages. Primary triage usually happens at the incident site, prior to patient transfer to a suitable facility with onsite critical care is prioritized. Secondary triage is hospital based and prioritizes patients for further diagnostic and therapeutic intervention. Tertiary triage is also hospital based, it involves the ongoing evaluation of therapeutic outcome and needs following admission to hospital. The triage category is not static, dynamic triage may change the category of the patient at any time.

Policy Making and Planning in MCI

Dealing with an overwhelming number of patients or any unusual circumstance requires appropriate institutional policy, planning, simulations and frequent audit cycles. The goal of care during an MCI, to save as many lives as possible with the given resources, can only be achieved if well-rehearsed protocols and policies exist, from triage to the provision of advanced care. In large scale disasters like pandemics, the WHO or other body may provide guidance. The primary responsibility of policy creation regarding care of victims lies with the national and state/provincial governments; such entities include the Emergency Management Framework in Canada and the Joint Commission in the United States of America.[7,8]

The period immediately following the incident is known as the "surge" period, in which hospital resources are rapidly used and possibly overwhelmed by the large number of patient casualties triaged, assessed and triaged within a very short period.[9] By comparison to man-made MCI, during a pandemic there may be a steady increase in patients over a longer period of time, a "protracted surge." Protracted surges can similarly overburden and overwhelm hospitals resources but over a longer span of days, weeks, or months. Policy and procedures may need to change quickly to adapt to the immediate needs of patients.

Following the announcement of an MCI, the Disaster Command Committee (DCC) or Emergency Medical Services should ascertain the surge capacity available at a facility. The destination facility should immediately attempt to increase capacity and resources to accommodate more patients.[10] Since the type and severity of injuries may vary depending on the mechanism of MCI, separate plans should be in place for each of the causative factors (natural or man-made). For example, contrast the resources and time scales expected to be required for a viral respiratory illness pandemic (eg, ventilators and personal protective equipment) with those for the victims of an explosion (eg, operating theatres and blood products). Depending on these plans, the series of events and involvement of various medical specialties, equipment or care locations may be very different. Hence, an institution should have a core framework for MCI, with specific plans and subsets of teams carrying out responsibilities superimposed in different circumstances. An MCI is announced as a separate code activation (code orange at most centers) to initiate the response (Fig 2).

The official declaration of an MCI and hospital notification often takes more than 30 minutes from an incident occurring.[11] The surge in patient volume after immediate onset MCIs such as explosions or accidents often peaks within 60-90 minutes, and most patients arrive within 2-4 hours.[12] Efficient automated methods of notification may save critical time during MCI.

In many MCIs, imaging is required to identify injuries, aid triage and guide management. Radiology is considered amongst the first responding in-hospital services.[13] If radiologists are not engaged with hospital leadership during the creation of these MCI plans, there may be misconceptions and false assumptions regarding radiology capacity and capabilities during disaster management. Good disaster management planning has shown improvement in the routine delivery of care with a decrease in the turnaround time of imaging.[14]

The stress of managing multiple acutely ill patients may hamper evidence-based practical decision making.[15] MCI response policies

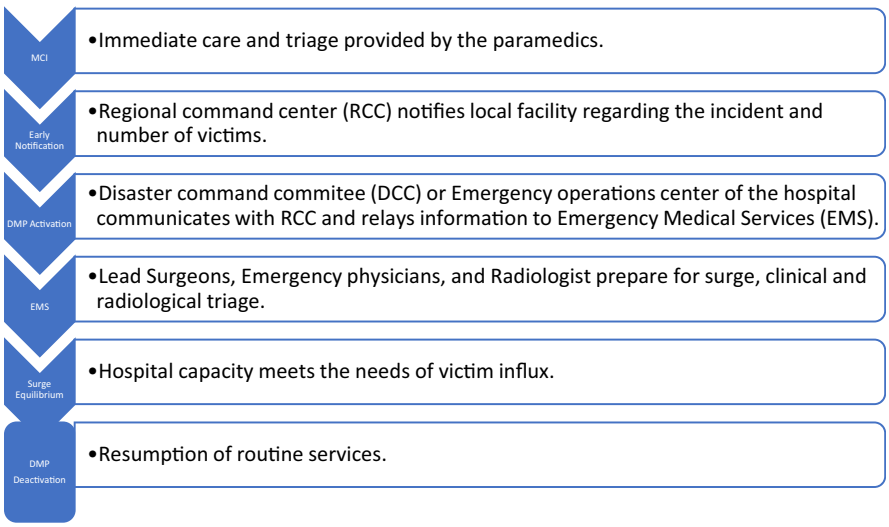

FIG 2. Schematic diagram of the sequence of events in MCI.

should clearly delineate the roles and responsibilities of the workers involved thus avoiding confusion in a high demand situation. The individuals providing prehospital care should be aware of the need for timely notification, triage, and transfer of patients to the facility. Health care workers involved in the hospital care of MCI victims and pre-existing patients should be aware of hospital policies, plans, and surge capacity.

Ethical Implications in MCI

During MCI, emergency health care providers might find themselves making challenging decisions that differ from normal care and which may lead to feelings of guilt or potential legal repercussions. Policies for the protection of frontline health care professionals volunteering and working beyond their level of training and expertise in such unusual circumstances should be developed at national level.[16]

Obligations and responsibilities of physicians to care for victims of a mass casualty incident are termed as virtue-based ethics, whereas, the medical decisions made by the physicians based on the availability of the resources, best chance of survival and prognosis of the victims are called utilitarian-based ethics. Pesik et al suggest that the physicians have no ethical obligation to accomplish anything that cannot be achieved due to lack of resources.[17]

The ethical obligation to care for a patient also carries a personal risk to MCI responders of being exposed to infectious diseases, radiation, or toxins in cases of pandemics, explosions, and acts of bioterrorism.[18] In a survey involving 744 physicians, Alexander et al found that 80% were willing to work when placed at risk, however, less than 45% felt prepared.[19] Besides personal risk, other important questions include issues of changing the status and priority of admitted patients unrelated to the MCI in order to cater to the needs of MCI victims who might have a better chance of survival if resources were instead used for their care.[20]

Resource utilization planning outlines physician roles (especially for those practicing outside their usual scope), transfer of care and how physicians will be relieved of duties, vaccination/treatment plans, and triage plans. Physicians should have access to essential equipment and should undergo extra training in its use, if required.

Policies regarding trainees, including medical students and residents, should be clarified in advance by the relevant bodies and program directors. Issues to be clarified in advance include the responsibilities of trainees to provide care during a pandemic and the potential effect of such an event on their personal well-being as well as on their education and training.[21]

Legal protection during disasters varies by jurisdiction, highlighting the importance of planned and approved disaster practices that can be invoked when required. Physicians should be reassured by the policy makers and politicians that they are safe to practice under such unusual circumstances rather than being “conscripted” by legislation.

In an MCI, a different standard of care is adopted. Minimum acceptable care for an individual institution should be defined in a multidisciplinary setting with legal and ethics representatives in attendance. Such measures provide important protection to the healthcare team, allowing them to focus on clinical duties during an MCI rather than being constrained by uncertainty. Steps should be taken to facilitate physician contact with their professional liability protection provider who should provide prompt access and updated information on their eligibility for protection in these circumstances. Furthermore, in order to ensure physician safety timely psychological support and counselling should be provided as required following an MCI.[22]

It is important for residents, as part of the clinical team and as future policy makers to have a clear understanding of the ethical considerations, professional obligations, standards of care and the reciprocal obligations towards physicians in order to improve the quality of care.

What Is the Role of Radiology in MCI?

A prepared Radiology department should have a process map of workflow from patient transfer to image acquisition, processing and interpretation. The departmental planning should address all issues from workforce, workflow, equipment and execution. The policies should also address the possibility of including radiologists in hands on direct care provision in the emergency department, for example, focused assessment with sonography in trauma scanning and image-guided intervention (eg, percutaneous aspiration and drain insertion).

The first step in radiological examination is the correct identification of the patient, a task made challenging by a large number of inbound patients, some of whom may be unable to identify themselves due to neurological injuries, hemodynamic instability or psychological shock. A unique MCI patient identifier should be provided to prevent confusion and conflict, which may be different from the hospital registration identifier.

The radiology service has the potential to become overwhelmed by the influx of MCI victims intersecting with the pre-existing scheduled studies and therefore nonurgent studies should be postponed as necessary.

Radiologists play an important role in secondary triage. Imaging should be reserved for those whose imaging findings will alter management, mostly patients triaged to the yellow category.[23] Over- and under triage are both dangerous and can affect mortality and morbidity. Mortality rate may increase as a result of overtriage saturating critical resources such as operating theaters. Direct linear relationship of over triage and critical mortality emphasizes the importance of triage accuracy.[24]

The utilization of imaging in the MCI setting is quite variable, depending on the institution and the nature of the incident. 92% of victims of explosions in a US military trauma hospital in Iraq required imaging including computed tomography, computed tomography (CT) (90%), radiography (70 %),and extended focused abdominal sonography, e-focused assessment with sonography in trauma (38%).[25] Imaging currently has an ongoing role in diagnosis, predicting the prognosis and treatment follow-up for patients with COVID-19.[26,27]

Residents should inquire about the following from their respective departments:

1. What is the institutional disaster management plan?
2. Who is the radiology department disaster management lead?
3. How can radiology residents contribute to the MCI?
4. What disaster planning simulations or drills exist??

What is the role of a lead radiologist?

The radiology departmental lead, typically an emergency/trauma radiologist depending on the site, should have knowledge of the capacity of the facility in relation to the number of victims as communicated by the DCC.[28] Identifying patients that require urgent imaging (triage) and how routine institutional practice should be diverted to cater to an MCI is expected to be planned and executed by the lead radiologist. This process is improved by practice and simulation. The lead radiologist should coordinate with interventional radiology, critical care, and the trauma team. The involvement of the lead radiologist in MCI alongside the lead emergency physician, trauma surgeon and anesthesiologist is critical.[5]

Steps that can be taken by a lead radiologist:

1. Familiarize the radiology team with the institutional and departmental DMP.
2. Ongoing communication with DCC or Emergency Medical Services.
3. Mobilize the workforce, including reporting radiologists and technologists as needed.
4. Coordinate and arrange equipment to be used in the MCI.

5. Establish an imaging examination ordering algorithm.
6. Accurate knowledge and estimation of turnaround time and waiting capacity, as this is vital to coordinate transportation of patients between departments.
7. Having an effective plan to facilitate prompt cleaning equipment and availability of personal protective equipment for staff in between patients.
8. Ensure efficient wet reading/hot reporting and result communication to the referring clinicians.

The capacity of a radiology department is determined by manpower, equipment and picture archiving and communication system (PACS) support. The radiology MCI team includes staff radiologists, fellows, residents and technologists that should be called in to acquire and interpret studies. The lead radiologist should assign roles and duties to the team members. The number of scanners and reporting workstations that can be deployed, and layout of the workflow should all be preplanned—including the logistics of transfer of patients to the scanner, waiting area capacity, scan time and transfer elsewhere in the facility after imaging. PACS support includes optimization of image data transfer and network traffic, aiming to prevent a data transfer bottleneck.[29]

Radiography is the most highly utilized imaging modality in MCI patients, with chest and extremity radiographs comprising the majority of studies.[6] Portable rather than departmental acquisitions are preferred, where possible, in an MCI setting to minimize patient transfer traffic. Portable ultrasound can facilitate focused assessment with sonography in trauma for operative triage, assessment of hemo/pneumothorax, solid organ injury, pregnancy, vascular injuries as well as vascular access, and even pediatric head exams.[30]

The imaging modality of choice for the detection of direct and indirect injuries in MCI is CT. Performing a whole body CT (WBCT, head to pubic symphysis) and avoiding the image processing by a technologist after each examination reduced the time delays up to 50% in a simulation study.[31] Unenhanced head CT followed by the WBCT may be performed in a single pass at an early venous phase or a split-bolus technique may be used, combining arterial and venous phases. Literature suggests the use of WBCT increases throughput and the number of examinations per hour.[31,32] For efficient image transfer and viewability, axial thick slice images (3- to 5-mm) should be sent to PACS in a soft-tissue kernel.[33] Postprocessing and reformatting of images should be performed at the workstations by the interpreting radiologist. Hot-read/wet reporting on the scanner immediately following the imaging helps detection of life-threatening emergencies such as tension pneumothorax or active hemorrhage.

Handwritten preliminary reports on preprinted carbon copy tick box forms detailing major life-threatening injuries in each body system is an efficient and effective way of conveying finding during MCI.[34] The value of describing important nontraumatic findings acutely is limited, detailed reporting of these imaging findings has the equivalent effect of over triage and the potential to increase mortality.[24] A second read over the next few days after the incident can act as a safety net in such instances describing the important nontraumatic findings and other incidental findings that may have been overlooked in the unique reporting environment that is an MCI.

After the acute phase of MCI has been managed, postmortem computed tomography (PMCT), also referred to as virtual autopsy, offers a practical, cost-effective, and informative alternative to traditional autopsy.[35,36] This has a role in assessment of injury patterns in an MCI and is important for future disaster planning. PMCT can not only accurately identify the cause of death but also indicate any shortcomings in early intervention on the part of the emergency response team. PMCT can be of value for identification in scenarios where victims have been severely disfigured. Especially in cases of explosions or fires, severely charred bodies may not yield adequate tissue specimens for biological sampling to undergo DNA analysis. Depending on the degree of thermal injury, the skeletal structure gets variably destroyed and the radiologist can guide the forensic team to residual tissue for analysis. The extreme carbonization makes for unfavorable dissection resulting in potential alteration in position of prosthesis or osteosynthesis and traumatic bone injuries. CT evidence, in such instances, can provide crucial evidence in lieu of DNA analysis to aid identification.[35,36]

The role of imaging in MCI patients is to increase triage accuracy, and early and effective communication of imaging findings, which can significantly reduce the burden on hospital resources as a result of over triage and improve care for patients, resulting in lower morbidity and mortality.

What Are the Future Areas of Development in MCI?

Advances in artificial intelligence (AI) can enhance the workflow in MCI. An AI supported and radiologist-centered framework can improve the workflow, image transfer and postprocessing during MCI. The use of such a framework, if efficacious, could provide considerable benefits for patient safety and quality of care, alleviating radiologist burnout, and decreasing healthcare costs over time. AI models are being used to support the protocolling of imaging studies to quicker postprocessing of imaging.[37]

Conclusions

Comprehensive knowledge of policies, plans, ethics and work dynamics during a mass casualty incident can help a radiology resident develop skills to effectively assist senior colleagues during a catastrophe. Knowledge of the importance of planning and simulation can provide them with a skillset that they can bring to any work setting.

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