Management of the 4th of August explosion in an orthopedics department

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Mass casualty incidents (MCI) are rare, large-scale events that result in heavy damage to people and infrastructure. These types of incidents result in a high influx of patients in local hospitals. In Beirut, this was witnessed on the 4th of August. A massive explosion took place in Lebanon's capital city Beirut. Although Hotel-Dieu de France Hospital was damaged, it played a crucial role in the management of numerous injured, especially in the orthopedics department. Six months later, the hospital contacted all patients that had been hospitalized during that night and the following 2 days for musculoskeletal injuries. The contact was done for feedback purposes as the event was considered one of the largest non-nuclear explosions in international history. Accordingly, most of the patients that were contacted gave a credible and positive rating. There were few who had suggestions for management improvement. MCIs are rare, but it is crucial to be prepared to face any edging situation. Having effective communication and an organized plan in any risk management process are essential tools to foster for the well of the community and to scale down the losses of the locals in the area.

Keywords:
emergency plan, explosion, hospital, mass casualty index, massive inflow of patients, orthopedics

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Introduction

Mass casualty incidents (MCI) are rare, large-scale incidents that result in heavy damage to people and infrastructure. These incidents are characterized by their diversity, quantity and severity to the patients whereby the local medical resources get overwhelmed and cannot deliver a comprehensive medical care. They can result from natural disasters, such as earthquakes, human carelessness, such as medical negligence, or terrorist activities. Such events are sudden and shocking; they are unexpectedly occurring. During such incidents, the hazardous and sudden impact poses a challenge to available medical resources, organizations and management systems in the local area. This is due to the resources being insufficient to meet the medical needs of all affected patients. Consequently, results to high morbidity and mortality rates are shown to have an increase among the impacted population. To be more precise with the definition a 'mass casualty incident' equates to a disaster, whereas 'multiple casualty incident' equates to an emergency [1]. From that perspective, MCI are characterized by having an overwhelming influx of patients towards healthcare centers and hospitals soliciting a great deal of resources and personnel [2–4]. Moreover, this influx will cause resources to become limited making the ultimate goal of any healthcare institution during an MCI to be to offer the highest amount of aid to the largest number of people with the scarce resources available. Musculoskeletal injuries are a common occurrence when faced with an MCI. This places orthopedic surgeons at the frontline of the patient care [1,5,6]. The scale and urgency of MCIs require a comprehensive strategy designed to cater to the different needs incurred in the fastest way possible.

On the 4th of August 2020 at around 6 pm, headlines were seen worldwide. These headlines all spoke about the same incident, the Beirut port explosion in Lebanon, which is considered one of the most powerful non-nuclear explosions in history.

This explosion was caused by a large amount of ammonium nitrate stored in the port. The death toll exceeded 200 and approximately 6500 were injured according to local authorities, causing a surge of patients striding into nearby hospitals which included Hotel-Dieu De France (HDF). The blast had an outstanding reach that had reportedly broke windows situated 9 km away from the port (Check Appendix 1 for view). HDF is located much closer and had been

under heavy damage, it remained functional and played a central role in taking care of the injured and saving lives. This article aims to describe the strategies taken by the orthopedic department in HDF to manage the crisis and analyze the results.

Discussion

Dealing with the crisis

Shortly after the blast, the healthcare team rushed to the hospital without being summoned. The staff initiated a humanitarian approach in order to aid as much patients as possible in the sense of trying to tackle as many patient as possible. The orthopedics department played a major role in crisis management. Some of the orthopedics residents and doctors were in the emergency room (ER) assessing patients, some of them were in the operating room (OR) treating severe and potentially fatal injuries and the rest were in the reception accepting the injured and fulfilling their needs. Communication between these different groups was a major component of the successful handling of this big catastrophe.

Emergency room

Chaos emerged and the healthcare team tried to be as strategic as possible. An organized pattern emerged and was immediately established with the rising inflow of patients. The pattern was described in a sense to make sure that all patients would get the attention they needed. It started with the injured patients coming into the hospital to get sorted in the ER depending on the severity of their injuries. Then, they were divided into three groups. The first group consisted of the patients presenting with a life or major limb threatening damage. This group was immediately directed to the OR for rapid management. The second group were the patients who hadf major injuries, but not life threatening. They were sent to the orthopedic ward for later definitive management. It is crucial to note that the surgeries related to the blast were performed till 5 days after this catastrophic event. The third group included patients with relatively minor injuries that included superficial wounds with or without extensor tendon involvement and excluding major flexor tendon or nerve injuries. This group was either managed immediately in the OR by residents under the supervision of the senior orthopedic surgeon or were sent home with a bandage and were asked to contact the hospital the next day to plan their surgery. These injuries were the most frequent as they were due to wounds caused by broken window glass. In the emergency room (ER) the use of wound stapler was very significant to the rapid management of wounds. It had aided in maintaining the flow of patients in the ER and gave time to focus on patients with more fatal injuries.

Operating room

In HDF, the orthopedic team is formed of 10 surgeons who work by subspecialty, to be more precise: 2 upper limb surgeons, 2 lower limb surgeons, 2 pediatric surgeons and 4 spine surgeons. During this catastrophe all available surgeons were operating on whatever patient was available in the OR. To reduce technical problems every surgeon would check between surgeries on all other operating surgeon thus giving his advice and if needed taking over the surgery if it was technically demanding and if it matched to his subspecialty. In this way all surgeries were done either by the corresponding subspecialist or under his supervision. Thirteen ORs were being used continuously for 48 h.

Orthopedic ward

Patients were hospitalized almost randomly in all hospital wards in the sense they would go to the nearest hospital or the one that would admit them. The senior attending surgeon nominated for each ward a different resident responsible for communication with the staff and for management of the hospitalized patients. His/her name and phone number were posted on the main board of the ward so that all the staff would know who and how to reach. This resident was also allowed to assist during surgeries in the OR, but would always contact the ward between surgeries to solve any pending issue. This was a crucial aspect that aided in the communication process between nurses, surgeons and management through the different issues that rose during this disaster. In addition to, every 12 h the senior surgeon did a complete check in the wards to reevaluate all orthopedic patients, organize the flow to the OR and to discharge patients as quickly as their medical condition would allow. In order to ease patient anxiety and avoid misdiagnosis, communication was established between injured patient and the clinical evaluation channels that described their medical status with the surgeon and residents. Post-operative clinical evaluation by the surgeon was also a major component in the successful management of these patients. Patients that were sent home and needed surgery were asked either to return to the ER in the next few days or to contact their orthopedic surgeons to plan the surgery. Any patient that entered the emergency department was required to give their information such as phone number, address etc. The procedure was also done to patients that were being transferred to the OR or orthopedics department, during the grand round and before discharge. After 6 months the patients were contacted, and data were collected concerning:

(1) location at the time of the explosion
(2) inquiry on patient reaching the hospital
(3) the date of admission to the hospital

(4) the delay between the admission to the orthopedics department and the diagnosis
(5) the number of contacted hospital before being admitted in HDF
(6) diagnosis
(7) management of condition
(8) the follow-up if there was any
(9) the patient's need for another surgery from a missed diagnosis or for a complication
(10) need to leave work
(11) the actual status
(12) satisfaction with the management on a scale from 1 to 10
(13) suggestions to improve the management in such conditions

Patients and injuries

When it came for musculoskeletal injuries, forty-eight patients were admitted. Patients were transported to the hospital in different ways. One the most common was through private vehicles and the rest were either in an ambulance or the Lebanese army. Some of them even came on foot. This behavior had been witnessed before. Patients during MCIs are very commonly transported through unconventional ways and rapid transportation is often advocated through such techniques (Harper and Rehman, 2015). It is important to note that most of the patients came directly to HDF, whereas a few of them had tried other hospitals before reaching HDF. At the time of the explosion, the patients that were admitted to the hospital were mostly in the neighboring regions. There were only few who came to HDF from distant ones. Patients who were admitted to the hospital from injuries related to musculoskeletal injuries of explosion counted 20.8% in the hour following the explosion. 70.8% of the patients came the day following the explosion and the rest which counted 8.4% came in 2 days after the explosion. The mean time between admission and diagnosis was 1.85 h ranging from 0 to 6 h.

Most of the admitted patients needed a surgery. Only 45 out of 48 patients had their diagnosis documented (Table 1) (Fig. 1).

Accordingly, the most common injuries were located in the upper limb followed by the lower limb. Afterwards came the ribs and the spine. It had been reported that the most frequently injured area was the lower limb followed by the spine and pelvic areas then the upper limb (Harper and Rehman, 2015). The different mechanisms of the catastrophe may be the reason behind these statistical variances. This data also showed that the patients who were closer to the site of explosion had more severe injuries than the ones who were further away. These injuries ranged from polytrauma to open fractures. Even though they were not very close to the site of the event, numerous patients had severe injuries such as shoulder fractures and tendinous ruptures due to the power and impact of this blast. The causes of major injuries had been due to intense exposure of the blast. For instance, lacerations, ruptures, nerve injuries and deep lesions were caused by glass shattering. Certain ruptures and fractures were caused by building collapses and damages or the patient had fell down from the explosion impact. It is important to note that lacerations, whether tender or skin, associated with bone fractures, would be mainly due to glass shatters or sharp objects like rock residue occurring from the blast.

Immediate follow-up

Upon completion of the surgeries and stabilization, patients were discharged from the hospital and asked to return for the outpatient follow-up. In order to remove sutures, fixatures and checkups, follow-up was crucial. Only 24 patients were reachable for questioning on the phone whereby 20 needed to be followed-up with. Accordingly, only 83% continued their follow-up at HDF, where they were initially admitted whereas the rest went to different hospitals. One of the patients treated for tendon rupture continued their follow-up at another hospital. The hospital switch was due to the fact that he used to be treated for there his medical issues. A second patient had her follow-up at HDF first where she had completed the surgery for fluid accumulation in the knee, but continued elsewhere due to the issue of the distance. A third patient started her follow-up at HDF; however, she had to continue at another hospital because she had difficulties in scheduling a follow-up meeting with her surgeon. She had a fracture in her fifth finger that was missed during the initial assessment. A fourth patient had a missed diagnosis which was a tendinous rupture of the extensors. Her surgery was scheduled at HDF 3 months after the explosion. All of these 20 patients had been in the active labor force before the explosion. However, 6 of them had to cease temporarily or fully working either due to the destruction of their job location or a needed rehabilitation period post-surgery.

Feedback

After the event, HDF conducted a study to showcase whether they had managed all involved patients with satisfaction and professionalism. The patients were given the opportunity to rate the management they had received on a scale from 1 to 10. After ratings were concluded, the mean value was 8.7. The feedback process included the patient that did not proceed with their follow-ups in HDF. There had been a rating of 1/10 due to the patient having issues with their insurance policies and the Ministry of Health

Table 1 List of different injuries and patient demographics (whereby M=male and F=female)

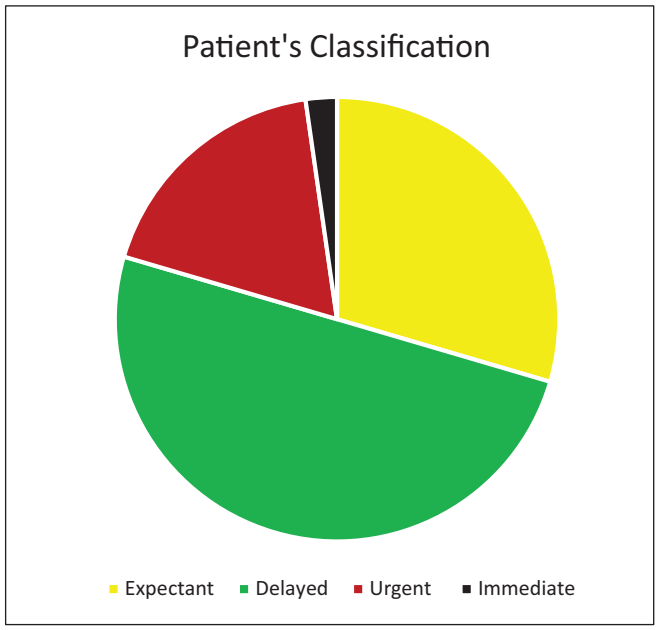
Case number	Injury	Sex	Age (years)	Triage category
1	Open tibial fracture	M	73	Urgent
2	Hand extensors rupture	M	70	Delayed
3	Intertrochanteric Femur fracture, costal fracture, olecranon fracture, wrist fracture	M	68	Delayed
4	Open luxation of carpal bones	M	38	Urgent
5	Cervical fracture	F	85	Urgent *treatment not surgery* (This patient needed a treatment to be done urgently, not an urgent surgery)
6	Commutative shoulder blade fracture	F	40	Urgent
7	Ulnar, radial and shoulder fracture	F	70	Delayed
8	Muscle laceration and tendon rupture	M	19	Delayed
9	Wrist fracture	M	47	Delayed
10	Shoulder blade fracture, hip fracture	F	90	Delayed
11	Lacerations of arm muscles	F	40	Urgent
12	Bilateral deep lesions of the hands	F	35	Urgent
13	Costal fracture and clavicular fracture	M	65	Expectant
14	Cupracondylar elbow fracture	M	38	Urgent
15	Siatic nerve rupture and tibial fracture	M	30	Urgent
16	Shoulder fracture	M	71	Delayed
17	Crushed wrist	F	40	Urgent
18	Multiple lacerations +right shoulder blade fracture +5th finger fracture+ right ankle sprain	M	72	Delayed
19	Patellar and tibial fracture	M	47	Urgent
20	Left hand extensors and flexors rupture	M	60	Delayed
21	Superior limb tendinous rupture	M	83	Delayed
22	Severe hemorrhage with no fractures (fear of variceal rupture)	F	84	Immediate
23	Brachial plexus lesion	F	47	Expectant
24	Proximal humerus fracture	F	50	Expectant
25	Knee trauma	F	60	Expectant
26	Lesions of arm, leg and extensors of the foot	M	68	Delayed
27	Deep lesion of the 3rd finger	F	93	Delayed
28	Wrist fracture	M	60	Delayed
29	Radial nerve injury	M	54	Urgent
30	Tendinous lesions in the arm	F	35	Delayed
31	Arm fracture with lesion of the extensors	F	56	Delayed
32	Deep lesion of the leg	M	28	Expectant
33	Ulnar fracture and costal fracture	M	40	Delayed
34	Polytraumatism	M	32	Urgent
35	Ankle edema with a trauma in the forearm and the skull	F	27	Expectant
36	Multiple fracture of the 1st, 4th and 5th metacarpals	M	45	Delayed
37	Radial fracture and ankle fracture	F	45	Urgent
38	Tibial fracture	F	49	Urgent
39	Radius fracture	F	71	Delayed
40	Thumb extensor rupture	M	70	Delayed
41	Facial lesions	F	75	Expectant
42	Achilles and flexor tendons of the hand rupture	F	39	Delayed
43	Metacarpal fracture	M	75	Delayed
44	Hand fracture	M	29	Delayed
45	Costal fractures	F	50	Expectant

and not with the management presented by HDF. Furthermore, a patient had rated the management with an average score of 6.5 due to having scars that turned into cheloid over time. The majority of the patients were highly satisfied from the management of the cases administered and had noted that it 'did not differ from a normal day in the hospital'. However, it was evident that only 4 patients suggested improvements targeting the insurance-hospital relationship and the suturing.

Results

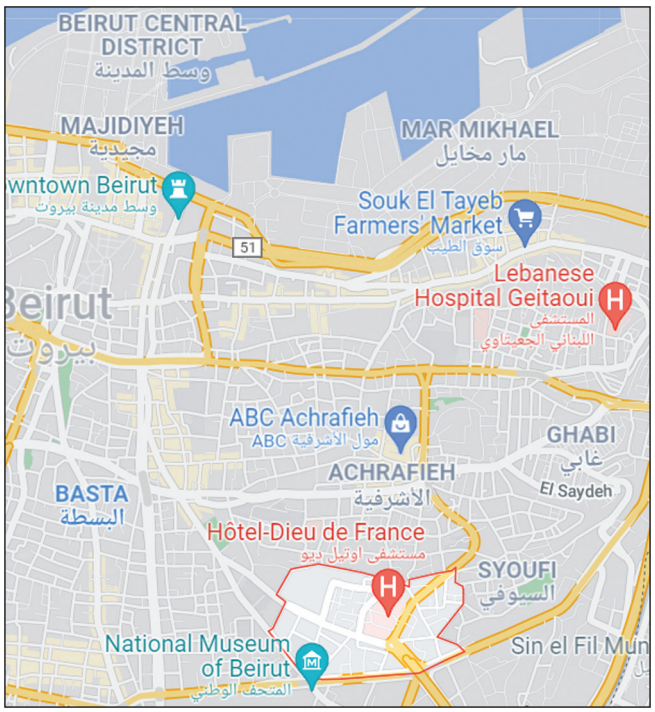
It is crucial after every incident to learn, correct and upgrade. The Beirut port blast was a significant lesson

Figure 1



Patients' classification in HDF.

Figure 2



Map view of Blast and HDF location.

not only to HDF, but all local hospitals. One major derived lesson is the importance of communication between the medical staff or with the patients. Communication had proved itself to be a tool for improving performances between the actors involved during the inflow of patients from the blast. Moreover, communication between patient and medical staff had proven itself to be an evident tool when it came to decreasing tension and anxiety of the patients at hand. This had been done through assuring patient that they will have the adequate treatment either immediately or delayed where this delay will not jeopardize the final outcome. Communication between surgeons had also been essential in establishing a plan for patient management. Each surgeon, according to his subspecialty, would give his recommendation for the management of the patient whether he would be performing the surgery or not. Moreover, the surgeon would also check during the surgery if any further management adjustment was needed. Efficacy of patient management had also been increased due to the effective communication between surgeons and the rest of the medical stuff. To facilitate this communication, a different resident was nominated for each ward. The name and phone number were available in the main office of each ward. This provided easy access to the surgeon when times were in dire need. It had been seen that immediate patient management was impossible to do for numerous victims as the influx of patients outnumbered by far the capacity of the medical staff. For this reason, the initial management should only include stabilizing the medical condition of the patient and plan the following treatment either immediately or later depending on the medical status. This delay can consist of a few hours or days after sterilizing and dressing the patients' wounds. One crucial aspect done by the management was the rapid discharge of patients from the ER or the ward was which aided in decreasing the patient load for bed availability. Also, using skin staplers in the ER and OR for wound closure was highly critical for rapid wound management.

The evaluations done from the hospital, before and after surgeries, proved to be a key in understanding the patient's case and avoiding misdiagnosis. This evaluation had aided th patients decrease their anxiety and feel secure about their treatment process.

An important factor that had been seen as a great lesson is the availability of the medical supplies. The time of the explosion occurred during dire financial and economic times for Lebanon. HDF had a concentrated management with the function to increase medical supplies stocks as it was predictable that the prices will go up or they are to be scarce. It is evident that having a storage of medical supply stocks is a factor that showcases whether a hospital can withstand an MCI or not.

Conclusion

Consequently, it is important to note that MCIs are faced unexpectedly. This was the case of Lebanon as it had tremendous outbreak on an international level.

The chaos created by this event to all local hospitals gave the medical institutions in Lebanon valuable lessons. Furthermore, patient had been proven to be in extreme frights and anxiety and it could be a possibility for further research to seek whether PTSD (Post-Traumatic Stress Disorder) was witnessed or not after MCIs. The key learning out of the Beirut blast for HDF hospital proved that consistent and effective communication relieves the anxiety of the patients and organizes the management of the hospital during the influx of patients. Moreover, the procedures of patient categorization should be done in organization in order to avoid diminishing resources and saving as many lives as possible. Furthermore. teamwork, devotion, and professionalism are important elements in succeeding patient management. Communication and establishing a rapid organization system are crucial in order to manage and reduce more chaos created by the event of the blast. In Lebanon, there is a lack and multiple deficiencies in the disaster and emergency response preparedness in hospitals [7]. This highlights the issue of a need for furthermore research on whether Lebanese hospitals are capable of withstanding MCIs of higher impact. Moreover, the study sheds light on issues related to medical insurance process and regulations during emergencies. Finally, it is crucial for all local hospitals in Lebanon to re-asses their emergency strategy and teams to be capable of handling influx of patients in an organized manner (Fig. 2).

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Not applicable.

Declarations
Approval and consent of the ethics committee has been received for the publication of this article.

Written informed consent was obtained from the patient for publication of this article AND any accompanying images.

Availability of data and material
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Conflicts of interest
There are no conflicts of interest.

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