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Neurosurgical Experience of Beirut Blast in the Era of Coronavirus Disease 2019 (COVID-19) from a Tertiary Referral Center

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■ **BACKGROUND:** In this paper, we shed the light on Beirut's blast that took place in the coronavirus disease 2019 (COVID-19) era. An explosion that ripped the heart of Beirut, it produced a destructive shock wave that left thousands of casualties and people homeless. This explosion, which had a mushroom-like cloud appearance similar to that of Hiroshima and Nagasaki, was described as the third-biggest explosion in human history. It was a blast that not only destroyed lives but also fell as a heavy burden on the shoulders of a country that was suffering from unprecedented economic crisis on top of the COVID-19 pandemic. Facing all this, health care providers were the first line of defense in what looked like an impossible mission.

■ **OBJECTIVE:** We seek to share with the medical community our experience and the challenges we faced, as a neurosurgery team, during this event, particularly that we were short of basic medical equipment as well as intensive care unit beds since we were in the middle of an economic crisis and the peak of the COVID-19 pandemic. This prohibited us from delivering proper care, whether in the triage of patients or in the operating room, as well as postoperative care. Now, 1 year after this sad event, we revisit the whole situation and examine all the pitfalls that could have been avoided. Thus, we discuss the importance of initiating a disaster response, in particular the neurosurgical emergency response, to be better prepared to face future potential events.

■ **CONCLUSIONS:** The rate-limiting step in such disasters is definitely a well-prepared trained team with a prompt

and fast response. And, since time is brain, then what saves the brain is proper timing.

INTRODUCTION

In 2020, Lebanon was experiencing a multitude of grueling challenges: pervasive political instability, economic collapse with the devaluation of the nation's currency against the dollar, and the additional complications imposed by the ongoing coronavirus disease 2019 (COVID-19) pandemic. Amid of all these challenges, we faced the third-biggest explosion in history. What was to come did not only resonate in the minds of the Lebanese civilians, but also those of every single physician who reported to duty on that day.

On a Tuesday evening at 6:08 PM on August 4, 2020, a huge explosion struck the city of Beirut, resulting in a shock wave that caused a powerful blast with a mushroom-like cloud (**Figure 1**). The devastating blast marked one of the biggest non-nuclear explosions in history, with 2750 tons of ammonium nitrate, equivalent to 500 kilograms of TNT, detonated through the heart of Lebanon's capital. Unfortunately, Beirut has already suffered from its fair share of explosions in the past, to name, among many others, a truck-bombing attack that detonated 5445 kilograms of TNT in 1983.¹

In this paper, we shall highlight our experience during this traumatic event that took place in the COVID-19 era, one that not only destroyed lives but also rendered the nation one of fading hope in both the eyes of the civilians as well as health care providers. What was endured from the neurosurgical perspective from the emergency department to the operating room and to

Key words

- Beirut
- Blast
- COVID-19
- Neurotrauma

Abbreviations and Acronyms

COVID-19: Coronavirus disease 2019

CT: Computed tomography

PPE: Personal protective equipment

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postoperative care will be emphasized. We will end by shedding light on the importance of initiating a disaster response, in particular the neurosurgical emergency response, to be better prepared for facing similar future potential events.

2020 BEIRUT'S EXPLOSION

A few minutes following the explosion, the code for disaster plan was immediately activated in the American University of Beirut Medical Center, which is 0.5 miles from the core of the explosion. Essential and nonessential health care workers reported to the hospital in anticipation of the number of casualties. The emergency department, in addition to its team, hosted residents from all surgical and nonsurgical specialties, intensivists, nurses, inhalation therapists, and clerks.

The rest of the hospital was trying to decongest and discharge as many patients to accommodate to the new influx of those who had sustained trauma. The availability of personal protective equipment (PPE) was scarce, and the ongoing infectious health emergencies had to be dismissed to harbor the new crisis. Routine COVID-19 testing was not an option, especially for patients who necessitated life-saving interventions.

Chief complaints with their various types of injuries were written on patient's bed sheets. Surgical teams were divided according to their area of specialty to benefit the most from every resident.

In a space that can only accommodate 42 patients, the health care team was now providing care to an inundation of casualties within a few minutes of the explosion. We divided our neurosurgical team, which consisted at that time of 1 attending and 3 residents, in a way that the most junior resident stayed in the emergency department, the senior resident was getting patients to undergo computed tomography (CT) scans and then to the operating room, while the most senior and the attending were operating. The neurosurgery team was in its entirety present, and every patient with head trauma was screened. Patients who were fully conscious and alert did not undergo any imaging studies. The neurosurgeon, health care staff, and even family members monitored others with minor deficits closely. Those with more severe injuries and a decreased level of consciousness were urgently taken to undergo CTs and life-saving surgery. Only 3 CT scan machines were available! Unfortunately, we were not able to screen everyone. Every case was documented not only with the neurosurgeon but stapled to patient's gowns; this allowed a concise follow-up and proper identification of all those who had sustained head injuries.

OPERATING ROOM EXPERIENCE

The scene was total chaos in the operating theater, yet organized with proper division of tasks. Medical and nonmedical personnel had not only previously rehearsed the code for disaster plans but also experienced a multitude of previous explosions and terrorist attacks in their career.² The nursing team played a vital role at the frontline in terms of anticipation, preparation, and management; this allowed 8 craniotomies/craniectomies to be performed within a mere 4 hours, 4 of which were performed in the first 90 minutes. Scarcity of resources was the only drawback that we faced, as a multitude of patients necessitated surgical intervention, so we were short on sterile equipment. Kits designated for general

surgery were used instead of neurosurgical ones, and we were left with only 2 drills, which had to be alternated and sterilized quickly in-between craniectomies.

Among all this, we faced other problems, mainly shortage of blood products as well as intensive care unit beds that were occupied by patients with COVID-19.

DISCUSSION

Lebanon, a small country in the heart of the Mediterranean Sea, faced the third-biggest explosion in history that emerged from the Port of Beirut. This explosion led to more than 5000 casualties (200 killed and 5000 injured) as well as 300,000 civilians displaced and homeless. In addition to the exhausted health care system due to the COVID-19 pandemic, damage to the nearby hospitals hindered the efforts to treat injured people. Because it was the closest hospital that was not heavily damaged, American University of Beirut Medical Center took care of the greatest number of the casualties.

Viewed through the eyes of the neurosurgeon, catastrophic events comprise significant lessons in mass casualty preparedness.² An environment suddenly filled with panic and terror will often lead to near-inevitable confusion and adrenaline-infused mistakes and multiple setbacks. We had limited resources in the emergency department as well as limited PPE with no access to our electronic data system, EPIC, due to a shortage of electricity and destruction of our utilities. Patient information was documented in notebooks or on patient gowns, and the results of studies ordered had to be followed up with the laboratory on a case-by-case basis until the next day, when we were able to access EPIC.

The amount of fear, uncertainty, and grief was beyond description. Among all this, delivering bad news, which we as physicians are used to, was a totally different game in this case. People watched us evaluating images and deciding that on who was salvageable and who wasn't. In the middle of all this, we were supposed to function beyond our capabilities. We ended up doing 8 craniectomies in 4 hours, 4 of which took place in the first 90 minutes after the explosion. Only 1 patient passed away, whereas another patient remains in a vegetative. The other 6 patients were discharged home, returning to their daily living. We were consulted on 15 cases; 8 were surgical and the others were minor trauma; 2 cranioplasties were done later on. Despite the pandemic, all patients took the appropriate care including ICU care with enough ventilators.

Practicing medicine in the traditional method was not attainable by any means. The ABCDE comprehensive model necessitates arrangement for adequate time in a private and comfortable location to communicate with family members, and both factors were almost nonexistent during the chaos. We had to rush from one patient to another to save as many people as we could.

No doctor or nurse had the time to check up on their own families; none of us were able to check the news to decipher what actually happened, with the exception of the occasional glimpses caught on televisions in waiting rooms that invoked more fear than understanding. We worked nonstop for hours without giving our mind the time to comprehend and digest how our beloved city was now torn to pieces.

The world also has witnessed a multitude of natural and human-made disasters causing tremendous burden on the



Figure 1. Beirut's August 4, 2020, blast.

suffering nation, be it socially or economically, leaving many lost lives behind. One way to decrease such losses is to be medically and surgically prepared at the site of the disaster before letting victims die of salvageable injuries.³ To successfully implement a disaster response, coordination between multiple government agencies in a timely manner has to be present.³ This will halt the need of any bureaucratic authorization that can slow down the disaster response.

An example on preparedness in times of disaster: the U.S. army built a mobile emergency unit that acts as a potential space to contain the injured and also as an operating room and recovery room that can be transported by helicopters,³ in addition to the use of lightweight devices that serve as cardiac defibrillators, monitors, and using mass oxygen distribution systems that provide oxygen for a larger number of casualties and portable CT scanners.³ What is more crucial to the availability of equipment on site is the availability of the physician/surgeon. This demonstrates the importance of telesurgery, which allows physicians to be present virtually and ready to help.³ This necessitates the presence of small, portable cameras to facilitate telecommunication. Other nations, however, have implemented health care guidelines to be used during disaster events, such as the Tactical Combat Casualty Care Guidelines set by the Australian government after facing multiple terrorist attacks.⁴

The guideline for field management of combat-related head trauma implies early detection of hypotension and coagulopathy, for coagulopathy is frequently present in traumatic brain injuries due to blood loss.⁵ Tunthanathip et al.⁶ found out that subfalcine herniation >5 mm and coagulopathy on admission were associated with poorer outcome in patients with blast-induced

traumatic brain injury, whereby they suggested reversing abnormal coagulogram to improve outcomes. Accordingly, ordering a coagulopathy profile for every patient with traumatic brain injury is important to early reverse any abnormality. The disaster caused by Beirut's blast necessitates the initiation of a disaster response that should be integrated in our health care system, in particular in the neurosurgery unit. We have encountered the blast with minimal number of surgical equipment in fully occupied operating rooms requiring the need of more space to operate. In addition, there was a scarcity in the surgical human power, as we were operating with an incomplete neurosurgical team that included only 1 attending for the first 3 hours. Above all, the shortage of PPEs in a place where the COVID-19 virus can potentially invade all of our systems posed a high risk of infecting our patients, whom we were doing our best to protect from further damage.

A disaster response can be activated when a similar disaster event is faced. Dedicated surgical equipment to be used only in times of need should be secured and stored. Furthermore, a special potential space with proper ventilating system against the COVID-19 virus should be allocated in the hospital to be used as operating rooms when needed. At our institution, we can make use of telesurgery by having a number of neurosurgeons available to be contacted when needed, since we have the equipment for the telecommunication interface. In this case, there will be no need to have an assistant surgeon in the room, which will allow more hands on to be available at the site.

In addition, forming a multidisciplinary team with psychiatrists is crucial.⁷ After encountering such traumas, mental stress and mental disorders such as anxiety and post-traumatic stress

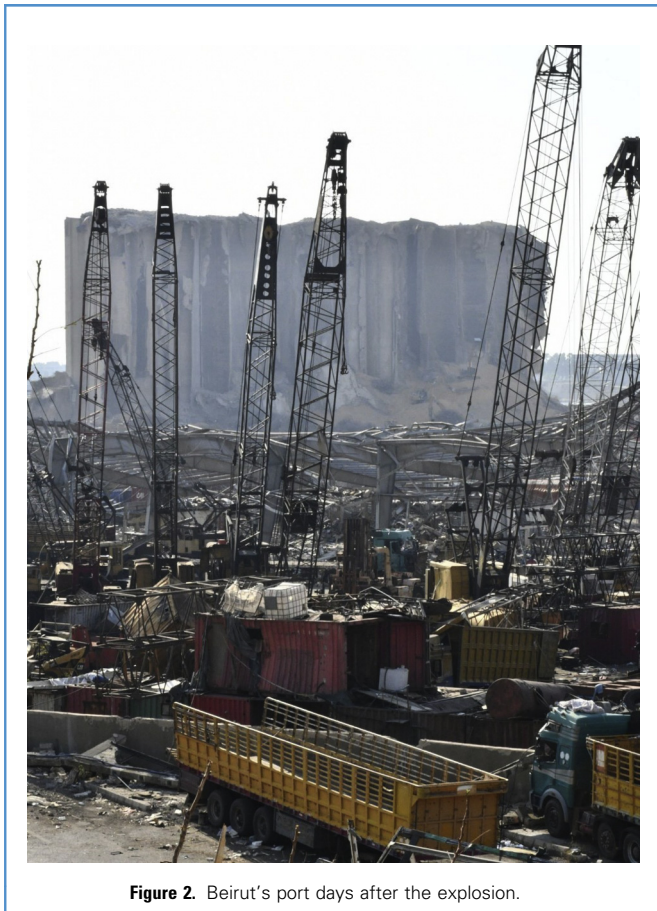


Figure 2. Beirut's port days after the explosion.

disorders arise and should be addressed.⁸ This is for the sake of both the medical team and the patients.

After all this chaos, the neurosurgery team resumed its regular function after 1 week once we made sure that no other casualties were to be transferred from other institutions. Finally, lessons have to be learned and things have to be changed at the level of preparedness.

CONCLUSIONS

War and neurosurgical comprehension have shared a reciprocal relationship that extends for millennia.⁹ The rate of brain injuries has been prominent in many explosive events, and hence it is crucial that the neurosurgeon who reports to the disaster is quick and accurate at performing immediate clinical assessments of neurologic status to intervene in a timely manner. All patients successfully underwent surgery. A small number did not make it to the operating room, and some

recovered and were discharged home. It was all a matter of time; after all, time is brain.

Lebanon is a nation equipped with strength and resilience, and health care providers have always tried their best to not succumb to its challenges. Nevertheless, the effects of the explosion cannot be neglected (**Figure 2**); the trauma that could not have been foreseen left a pain that lurks in our souls until this day. Teamwork and collaboration proved not only essential but vital to the survival of many victims. A proper disaster response plan is required to better handle such events.

Fortunately, many have survived, and many continue to recover, but we question whether we truly survived at all. For Beirut, we hope it will be just to its people, not just merciful.¹⁰

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REFERENCES

1. Scott BA, Fletcher JR, Pulliam MW, Harris RD. The Beirut terrorist bombing. *Neurosurgery*. 1986; 18:107-110.
2. Hubbard ZS, Henderson F, Armonda RA, Spiotta AM, Rosenbaum R, Henderson F. The shipboard Beirut terrorist bombing experience: a historical account and recommendations for preparedness in events of mass neurological injuries. *Neurosurg Focus*. 2018;45:E18.
3. Andrews RJ, Quintana LM. Unpredictable, unpreventable and impersonal medicine: global disaster response in the 21st century. *EPMA J*. 2015;6:2.
4. Rosenfeld JV, Mitra B, Smit V, et al. Preparedness for treating victims of terrorist attacks in Australia: learning from recent military experience. *Emerg Med Australas*. 2018;30:722-724.
5. Brain trauma New York. Brain Trauma Foundation. Available at: https://www.braintrauma.org/guidelines/uploads/02/09/btf_field_management_guidelines_2.pdf. Accessed June 23, 2019.
6. Tunthanathip T, Khocharoen K, Phuenpathom N. Blast-induced traumatic brain injury: the experience from a level I trauma center in southern Thailand. *Neurosurg Focus*. 2018;45:E7.
7. Rathore FA, Gosney JE, Reinhardt JD, Haig AJ, Li J, DeLisa JA. Medical rehabilitation after natural disasters: why, when, and how? *Arch Phys Med Rehabil*. 2012;93:1875-1881.
8. Randolph R, Chacko S, Morsch G. Disaster medicine: public health threats associated with disasters. *FP Essent*. 2019;487:11-16.
9. Frykberg ER, Tepas JJ 3rd. Terrorist bombings. Lessons learned from Belfast to Beirut. *Ann Surg*. 1988;208:569-576.
10. Morcos JJ. Brief encounters that last a lifetime: an immigrant neurosurgeon's reflections on American exceptionalism, George Floyd, sunlight, and race [e-pub ahead of print]. *J Neurosurg*. <https://doi.org/10.3171/2020.7.JNS202686>, accessed August 7, 2020

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