

Original Article

Response of a single European burn center to Centelles mass casualty burn disaster: enzymatic debridement utility

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Abstract: Introduction: Mass burn casualty disasters present with a big challenge due to the complex multidisciplinary management of severely burned patients and the limited capacity of the specialized centers. Literature is scarce, and so is the management of these disasters with enzymatic debridement (ED). Methods: Retrospective observational analysis of nine patients admitted to the Vall d'Hebron University Hospital Burn Center (Barcelona, Spain), as a consequence of a bell tower explosion on December 30, 2019. The patients with intermediate-deep second-degree burns, either in circumferential or affecting highly functional areas as hands, feet or face, were included in the ED group. Continuous variables are expressed as mode and standard deviation and quantitative ones as percentages. Results: Fourteen people were injured after the explosion of gunpowder-containing bags in a bell tower during a cultural celebration. Nine casualties (6 men and 3 women) suffered burn injuries that required assessment and admission in our Burn Center. The mean age was 44.33 years (range 19-61 years), with burns covering a mean total body surface area (TBSA) of 15% (range 5-48% TBSA). One patient required invasive mechanical ventilation and intensive care management. Seven patients required ED, with an average debrided TBSA of 6.1% (range 3-10% TBSA). Seven out of 9 patients required at least one surgery. The average hospital stay was 23.33 days (range 2-53 days). No escharotomy was required and no patient died. Conclusions: This experience brought out the weak and strong features of our center when facing a situation that implies an important care stress. It can be useful for other Burn Centers in similar situations in the future. We found that new tools, such as ED, can be advantageous in such situations.

Keywords: Burn, multiple burn victims, mass casualty disaster, fire disasters, burn center, enzymatic debridement

Introduction

A mass casualty event is an emergency that can push the boundaries of the regional emergency services and hospital centers and they may even exceed the available resources [1]. There are some publications that analyse the responses to some major catastrophes, both from a global point of view [2-4] and others with a specific center perspective [5, 6]. These evaluations contribute to a better understanding and management of those events [7]. Nevertheless, we have found no references of accidents that, despite having a lower number of casualties, all of them are assisted in a single Burn Center.

In the last years, our region faced some situations that required an important effort from our center, such as the terrorist bombing of the department store Hipercor in Barcelona in June 1987, with 21 deaths and 45 injured [8], the explosion in Gavà in 2008, with 7 deaths and 21 injured [9], and the explosion of a gas carrying tanker truck in a road located next to the Los Alfaques campground in 1978, where 215 people died and 175 were injured [10].

Our center has been using ED since 2015, so the familiarity with this treatment let us use it in a mass burn casualty event. It allowed us to treat a large number of patients in the first 24 hours without the need of an operating room.



Figure 1. The bell tower seconds after the explosion (retrieved from Twitter with permission from the author).

The objective of this research is to show the characteristics of the accident occurred in Centelles (Spain) on December 30, 2019, the response of our Burn Center and the lessons learned from this event.

Methods

A retrospective descriptive analysis was carried out from digitalized clinical database of nine patients admitted to the Vall d'Hebron University Hospital Burn Center (Barcelona, Spain) on December 30, 2019, as a consequence of the explosion in a bell tower in Centelles (Barcelona, Spain). We included only the victims transferred and admitted to our Burn Center; casualties attended at the scene and not transferred were not considered. Moreover, the patients with intermediate-deep second-degree burns, either in circumferential areas or affecting highly functional areas as hands, feet or face, were included in the ED group. The following variables were collected: gender, age, length of hospital stay, TBSA for second and third-degree burns and affected areas, need of ED, local infection and need of surgery. The continuous variables are expressed as mode and standard deviation and the quantitative ones as percentage.

This study was approved by the ethics and clinical research committee of our center: PR(ATR)486/2020. Some press reports were added to complete the chronicle of the event.

Results

The accident

Centelles is a small town located 50 km north from Vall d'Hebron University Hospital in

Barcelona. This town celebrates annually the “Festa del Pi”, a cultural festivity in which a pine tree is carried from the forest to the town’s church, while the “galejadors” fire their weapons charged with gunpowder [11]. Apparently, on December 30th, 2019, while some of these “galejadors” were in the bell tower, one of the bags containing gunpowder exploded and it spread to the bags of the people around. This chain explosion resulted in a big deflagration in a demi-closed space that caused wounds in 14 people among “galejadors” and photographers. **Figure 1** shows the location of the accident few seconds after the explosion.

Notification and patient transfer

Our center received the first notification approximately at 2 pm. The first call reported 14 casualties: one severely burned patient and more patients with milder lesions that could require derivation to our center. There were 2 plastic surgeons (one of them a trainee) and 3 intensive care specialists on call. Two plastic surgery trainees reinforced the on-call team because of the potential huge number of patients expected. Of note, the accident occurred during the Christmas Holiday peak season with part of team on leave. Subsequently, the emergency services confirmed the transfer of 2 severely injured casualties and the on-call team agreed to transfer and assess the patients with milder lesions gradually (in that moment 10 patients were reported). Following the Mass Disaster Protocol of our hospital, the clinical head of our Burn Center joined the team to offer his support.

The first patient arrived transferred by helicopter at our center at approximately 3 pm. Few minutes later 2 other patients arrived by ambulance and one hour later, the last 6 patients arrived by ambulance too, all of them at the same time.

Patients and hospitalization

Nine patients (3 women and 6 men), with a mean age of 44.33 years (range 19-61 years) were assessed in the emergency room of our Burn Center, all of them requiring admission. The average burn extension was 15% TBSA (range 5-48% TBSA). Data is summarized in

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Table 1. Patient data and summary of hospitalization

Patients	TBSA (%)	Burned areas	ED	Hospital stay (days)	Surgeries
1	48	Face, upper limbs, lower limbs, gluteus, trunk	Yes	53	3
2	18	Face, upper limbs, thighs, abdomen	Yes	25	1
3	15	Face, right upper limb, hands, trunk, lower limbs, right flank	Yes	32	2
4	12	Face-neck, upper limbs, lower limbs	Yes	17	0
5	12	Face-neck, hands, legs, right thigh	Yes	25	1
6	12	Face, thigh, right upper limb	Yes	28	1
7	8	Face-neck, hands, lower limbs	Yes	24	1
8	5	Face, trunk, forearms, left hand	No	4	1
9	5	Face, right upper limb	No	2	0

M: Male; F: female; TBSA: Total Body Surface Area; ED: Enzymatic debridement.



Figure 2. Most burns were intermediate-deep second and third degree burns and were located in face and upper and lower limbs.

Table 1 and **Figure 2** shows the distribution of the burned areas.

One patient required invasive mechanical ventilation because of the deep burns in the facial area. Five patients had circumferential burn injuries on their limbs (12 limbs in total, 8 upper and 4 lower limbs) with potential risk of compartment syndrome; no escharotomy was required. In contrast, ED (NexoBrid[®], MediWound, Germany) was carried out in all of them. ED was applied also in the facial area of the patient that required mechanical ventilation and in no circumferential burns affecting hands. In overall, seven patients were treated with ED in any body surface.

The two patients that were not candidates for ED had superficial second degree burns in

facial areas and hands (approximately 5% TBSA) and were admitted to our hospital to assess facial edema and rule out any potential airway complications. Both were discharged two days afterwards. One of them required elective surgery few days later to cover the non-healing wounds in hands with skin grafts.

Seven patients required one or more surgical interventions, with an average of 1.11 surgeries per patient (range 0-3 surgeries). Surgery consisted in tangential excision and autologous skin grafts in all of them, except for the most severely burned patient, who required tangential excision and homografts before the definitive coverage with autologous skin grafts.

The mean hospitalization stay was 23.33 days (range 2-53 days). No patient died.

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Table 2. Enzymatic debridement (ED) summary

Patients	Days since accident	Areas	Local infection	Surgery NEED after ED
1	0	Face Hands	No	Hands
2	0	Hands Forearms	No	No
3	+1	Hands Right upper limb	No	Right hand Right upper limb
4	0	Hands Knees	No	No
5	0	Hands	Yes (<i>S. aureus</i>)	Hands
6	+1	Right hand Right upper limb	No	Right upper limb
7	+1	Hands Right upper limb	Yes (<i>E. coli</i> , <i>S. aureus</i> , <i>K. pneumoniae</i>)	No

Enzymatic debridement (ED)

According to our center protocol, all intermediate-deep second-degree burns, either in circumferential areas or affecting highly functional areas as hands, feet or face, are tributary for early/immediate ED with NexoBrid® [12-16].

Seven patients (78%) met the criteria. Due to the logistic impossibility of applying the product to all of them in the same afternoon, we prioritized the patient with deep burn injuries to the face and those who had deeper and/or circumferential lesions with a higher risk of developing complications as compartment syndrome. ED was performed in 4 patients during the first afternoon, all of them in upper limbs and two of them also in facial area and circumferential wounds on their knees. The other 3 patients were treated with ED the next morning. The average debrided TBSA was 6.1% (range 3-10% TBSA). We followed the ED protocol of our Burn Center in every patient. Data is summarized in **Table 2**.

Fourteen out of 21 (66.7%) areas treated with ED, which we initially considered that would need surgery, healed spontaneously without surgery in 35.07 days on average (range 16-59 days). Moreover, we observed a reduction of the extension in grafted areas in all the areas that required surgery after ED. Two patients developed local infections in areas treated with ED (hands in both cases), *S. aureus* was identified in one of them and *S. aureus*, *E. coli* and *K. pneumoniae* in the other one. One of the patients required surgery for coverage as soon as the infection was controlled and cleared.

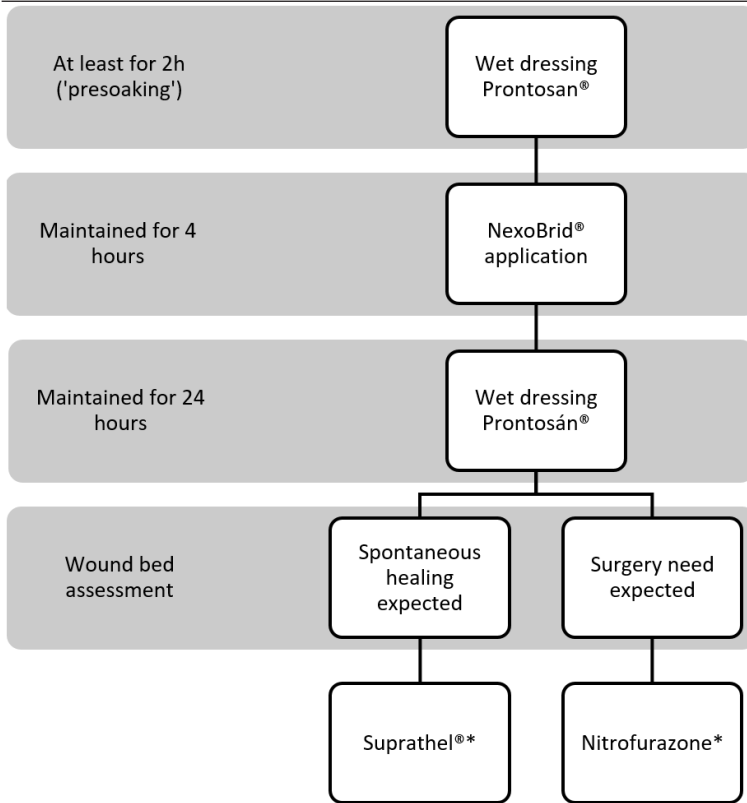
After the post-ED assessment, all the wounds were considered to have spontaneous healing potential without surgery. Therefore, according to our protocol that is shown in **Table 3**, the elective dressing applied was Suprathel® (Polymedics Inc., Germany). Unfortunately, due to the Christmas Holidays there was a shortage of product (limited resource by the company) and only some of the patients could be treated with Suprathel®. Therefore, we prioritized this dressing for the superficial wounds after ED and the rest of the wounds were treated with nitrofurazone based ointments. These dressings were discontinued and replaced with Suprathel® as soon as it became available. The facial area was covered with Medihoney® (Medihoney Pty Ltd., Queensland, Australia).

Discussion

A mass burn casualty disaster is defined as an event in which the number of victims exceeds the capacity of the local burn center to provide optimal burn care. It poses an extreme stress to the emergency and health system of the region [17]. It is not defined by the absolute number of casualties, but by the capacity of the event to disrupt local resources [5, 18]. Some authors suggest that the acute treatment of 2-3 severely burned patients require to increase the capacity of facilities, and accidents with 20 or more victims can produce a collapse even in the most modern and equipped centers [7]. Our center has 20 regular hospitalization and 6 intensive care beds. Therefore, the admission of 9 acute patients that required specialized techniques in a unit that, like most Burn Centers, is usually in its high occupancy

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Table 3. ED application protocol in Vall d'Hebron University Hospital Burn Center



Prontosan® (Polihexanida 0.1%, Braun Melsungen AG, Germany); NexoBrid® (Medi-wound, Germany); Suprathel® (Polymedics Inc, Germany). *In facial area Medihoney® (Medihoney Pty Ltd., Queensland, Australia) is another option usually applied.

limit [1, 19], produced an important stress that was managed with an extra effort of the hospital staff.

We consider that every hospital or sanitary area with a Burn Center should have a protocol to guide the assistance in mass casualty events, with the aim of optimizing the patient's triage, transfer, derivation and, finally, the treatment that they receive. Nowadays, we have a protocol agreed with emergency services and firefighters and some preliminary contacts are in place to renew the protocol of MCI (Multiple Casualty Incidents) for burn victims in the area of Barcelona. Similarly, the EBA (European Burns Association) has started an international plan to face catastrophes through the collaboration among Burn Centers from different countries, including our center [20, 21]. These strategies enable to have clear guidelines, avoid improvisation and facilitate a more efficient

use of the resources in such complex situations.

A key objective in these situations is to avoid overwhelming specialized centers with minor casualties in order to focus all resources in the most complex patients and distribute the patients to prevent the simultaneous arrival of cases not requiring immediate attention [2, 22]. In our case, as per our Mass Casualty Protocol we agreed to assist all the patients after the confirmation of the total number of victims, but only on condition that the transfer was staggered. However, after the arrival of the first 3 most severely injured patients, 6 other patients arrived at the same time at our emergency room. It seems to be a consensus that severe patients (>20% TBSA) should be transferred to a burn unit for evaluation and treatment [2]; although, burn injuries in functional or cosmetic important areas, that in other circum-

stances should be evaluated in a specialized center, would not be derived, at least initially, to a burn unit [1]. This situation could have been avoided attending the patients in non-specialized hospitals close to the accident location, coordinating later, if necessary, the transfer to our center once we had attended the most severe patients [17, 19, 23].

Before the arrival of the first patients, we redistributed the milder patients of our unit in other units of our hospital with the aim of having available beds for the expected patients. When 6 patients arrived at the same time, we had to prepare the room where ambulatory patients are normally treated as an emergency room. This was possible because we have a multidisciplinary unit that has an emergency room, wound-dressing room, hospitalization rooms and an operating room in the same unit. The fact that two plastic surgeon trainees stayed

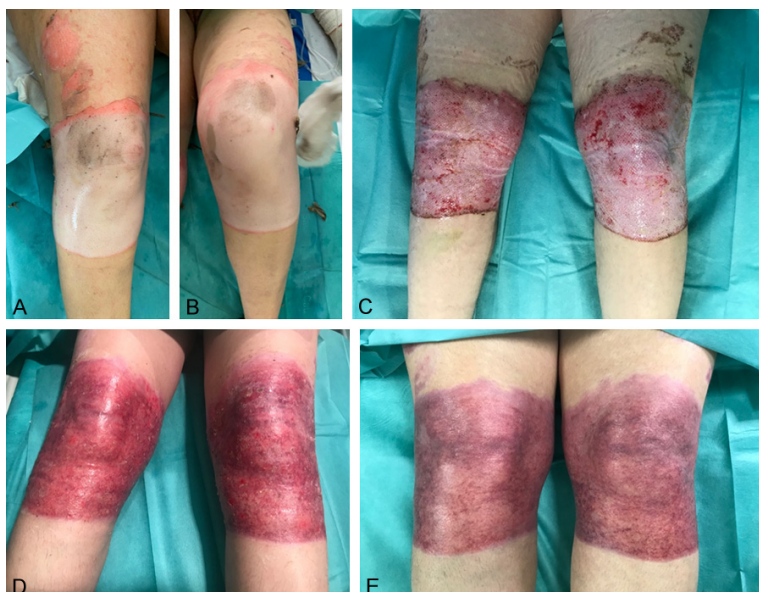


Figure 3. Patient with deep second - third degree circumferential burns in both knees. ED was applied some hours after the accident and posterior dressings consisted in nitrofurazone ointments. Initially, surgery was scheduled, but due to the good evolution of the wound, it was suspending and complete healing was achieved without skin grafting. A, B. Pictures taken during the first assessment in the emergency room. C. Day 12, big areas with deep appearance. D. Day 30, almost complete healing with residual wounds. E. Day 44, uniform epithelialization waiting for scar maturation.

in the hospital and the coordination with the nursery team and other services like anesthesiology (who performed the nerve blocks before ED) allowed to speed up the evaluations, decision making and interventions. However, in a posterior discussion and audit, we concluded that we faced a stressing situation that could have been prevented with a better planning.

The use of ED in these patients contributed some advantages. In one hand, as there is no need of an operation room to apply the product (it is carried out in the emergency or wound-dressing room) and the procedure is performed by the nursery staff after a first evaluation by a plastic surgeon, we could perform an early debridement of an important number of patients; without ED, this would have not been possible. ED was performed in all cases within the first 24 hours of hospital admission. It also allowed us to maintain the surgical planning of the unit during the next days. In the other hand, it was very useful to prevent compartment syndrome in circumferential burn injuries in extremities [15, 16, 24, 25]; we did not have to perform any escharotomy, as shown in

Figure 3. In these cases, ED is conducted as soon as possible and must not be delayed for the eschar presoaking [15, 16]. Finally, we consider that the number of surgical interventions was lower than previously estimated in the first clinical exploration. 67% of treated areas did not require any surgery, despite all of them seemed to be intermediate second degree or deeper initially. **Figure 4** shows the evolution of the facial area treated with ED.

Conclusions

After revising our response to the event, we consider all patients received a correct attention, even though the coordination of the patient transfer was not well conducted. We highlight the importance of the pre-established protocols to improve the actu-

ation in this kind of accidents and all the actors in the incident to follow them; in our case, we could manage the situation with an extra effort from the health personnel, but this could not be enough in future events with more casualties or more severely injured ones unless all emergency systems active and do follow the protocol. Regarding the lack of materials, we decided to have a stricter control of the warehouse, especially before periods in which getting new supplies could be difficult (peak holiday seasons). ED enabled us to treat a large number of patients in the early stages of medical care. We could prevent potential complications as compartment syndrome, and, afterwards, reduce the number of surgeries needed and the total surface area requiring surgical intervention. We consider it a useful tool in similar situations when used by an experienced burn care team.

Disclosure of conflict of interest

None.

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Figure 4. Deep burns in facial area treated with enzymatic debridement and posterior application of Medihoney®. Complete healing was achieved without need of surgery, with a good cosmetic result. A. Pictures taken in the emergency room. B. Just after removing the enzymatic product (it was maintained for 4 hours). C. 24 hours after ED. D. Day 30, complete epithelialization, good cosmetic result.

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