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Clinical Paper

Lightning injuries in Northern Ireland

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ABSTRACT

Introduction: Lightning injuries are uncommon in Northern Ireland (NI) with scarce reports detailing incidence and local experience. We present a case study of 3 patients involved in a single lightning strike with a review of the incidence of similar injuries in the province.

Methods: Data from TORRO's National Lightning Incidents Database between 1987 and 2016 (30 years) were searched to identify victims of lightning injuries in NI. Information on 3 patients with lightning injuries that were managed in our regional burns and plastic surgery service was collected and examined. A supplementary search in hospital records was conducted over the last 20 years to identify additional data.

Results: Prior to our study, 6 victims of lightning injuries were identified of whom 5 survived and 1 died. Our 3 patients comprised of 2 children and 1 accompanying adult. All survived but the adult suffered cardiac arrest and required a prolonged period of cardiopulmonary resuscitation.

Conclusion: While lightning injuries are rare in NI, this is the first report of more than one person affected by a single lightning incident in the province. In our limited experience, immediate public response and prolonged cardiopulmonary resuscitation efforts facilitated by automated defibrillators result in a favourable outcome.

BACKGROUND:

In the United Kingdom (UK), lightning strikes are relatively uncommon compared with other areas of the world. Consequently, reports in the local medical literature on occurrence, morbidity and fatality are relatively scarce.

The Tornado and Storm Research Organisation (TORRO) collects data on national lightning incidents in the UK. For the purpose of our study, we searched this database over a period of 30 years (1987-2016) to review the incidence of lightning strikes and associated injuries and deaths in the UK

METHODS

Data over a period of 30 years were examined from TORRO's National Lightning Incidents Database between 1987 and 2016 with reference to NI. A supplementary search over a period of 20 years (1997-2016) of the records of the Burns Unit in the Royal Victoria Hospital and the Royal Belfast Hospital for Sick Children was conducted using the ICD-10 code X33, which is specific to victims of lightning, to identify other patients. Information on 3 patients with lightning injuries managed recently in our regional burns and plastic surgery service was collected and examined.

RESULTS

The TORRO data over a 30 years period showed that 8 survivors and 1 fatality were recorded in Northern Ireland between 1987 and 2016. The one fatality recorded was an off-duty soldier struck on the Mourne Mountains in 2006.

The hospital data search did not identify any other cases.

The 3 victims recently treated in our unit were struck by lightning in the city of Lisburn. Their cases are presented below:

Case 1:

A healthy man aged 36 was struck by lightning while accompanying his two children (aged 5 and 7 years) from school. The lightning bolt struck him directly causing cardiorespiratory arrest and splashed over his children. Basic life support was initiated almost immediately at the scene by members of the public. Advanced cardiopulmonary resuscitation was commenced by the arriving paramedic team. The initial recorded rhythm was pulseless electrical activity (PEA), which subsequently converted to ventricular fibrillation. The patient was transferred to the Accident and Emergency Department. Spontaneous return of circulation

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was established 50 minutes after the incident. The combination of lightning injury and extended resuscitation period had caused severe metabolic acidosis, hypoxic brain injury and multiple organ failure. The entry wound, which was found at the left side of the neck, had caused a deep dermal burn. The current travelled down the contra-lateral side exiting at the right big toe causing a full thickness burn.

On arrival in Intensive Care, he was critically ill with persistent circulatory failure requiring high volume fluid resuscitation and high dose inotrope therapy. Continuous renal replacement therapy (CRRT) was commenced for this and refractory hyperkalaemia with evidence of considerable rhabdomyolysis (CK 10264 U/L (normal range 40-320 U/L)). He had severe acute respiratory distress syndrome and received lung-protective mechanical ventilation. By the third day, he remained in multiple organ failure with persistently elevated serum lactate levels. He was too unstable for CT scan transfer and underwent an exploratory laparotomy and limited fasciotomies of his right upper and lower limbs. The laparotomy revealed a liver laceration which was packed, whilst his compartments were found to be healthy. On the fourth day, he returned to theatre for further assessment, removal of packs and definitive closure. He was subsequently weaned off inotropes. On the sixth day, he became less dependent on CRRT and a CT scan of his brain and spine was performed. It showed left temporal ischemia, a small subarachnoid haemorrhage and loss of grey-white matter differentiation in-keeping with hypoxic brain injury. This was subsequently confirmed on MRI imaging, MRI of spinal cord was unremarkable.

Fig 1. Lightning burn scar 1 year following the injury

His condition stabilised, and a tracheostomy was inserted on the eleventh day. His renal function recovered and dialysis was discontinued after 20 days. He exhibited profound weakness and underwent neurophysiological studies which showed patchy peripheral neuropathy with axonal loss affecting both motor and sensory fibres. Muscle biopsy showed only patchy neurogenic myopathy with many preserved muscle units on electron microscopy. After a period of confusion, his conscious level improved towards baseline and he made slow progress with intensive multi-disciplinary rehabilitation. Tracheostomy was removed after 33 days and he was discharged from ICU after 49 days. He was transferred to the Regional Brain Injury Unit after 12 weeks and discharged home 26 weeks following his initial presentation. He had progressed well, however he suffered continued weakness of his proximal muscles and mobilised with the help of a crutch. His wounds healed completely without surgical intervention (figure 1)

Case 2

The second victim was a 5-year-old boy walking on the left side of the adult – he sustained a splash type of injury. He suffered a seizure at the scene and was transferred to the emergency department. Endotracheal intubation was performed. CT scan of the head and MRI scan of the neck showed no abnormality. Serum troponin was only mildly elevated (41 ng/L, normal range <14ng/l.). Bedside echocardiogram and ECG were unremarkable.

Fig 2. Left lower limb of the 5-year-old boy showing superficial partial thickness burn and erythema

The lightning splash injury caused a burn to the right occipital area, right side of neck, abdomen, perineum, left lower limb (figure 2) and an exit burn at the plantar aspect of right big toe.

(figure 3) The total body surface area (TBSA) burned was 4%. His burns were largely superficial partial thickness (treated conservatively) and a small area of full thickness burn at the right big toe. He recovered well without residual disability and was discharged home six days after the injury. The full thickness burn on the big toe was excised and resurfaced with a split skin graft 4 weeks later.

Fig 3. Right big toe of the 5-year-old boy showing full thickness burn

Case 3:

The third victim was a 7-year-old girl walking on the right side of the adult at the time of injury. She also suffered a splash burn from the lightning, approximately 3.5% TBSA, on left upper limb, groin and exit burns on both feet. Keraunographic markings (Lichtenberg figures) were evident on both lower limbs. These were superficial partial thickness burns except a very small area of deep dermal burn at the left forearm. She did not suffer any other serious internal injuries. After six days of hospitalisation. She was discharged home with outpatient follow up plan. Her burns healed 18 days following the injury.

DISCUSSION

Lightning is a high voltage electrical discharge with a massive current ranging from 30,000 to 110,000 amperes (A), although such currents are only applied for 10 to 100 milliseconds (ms)[1]. Energy transfer to the body is therefore limited. Cloud-to-ground strikes can cause significant damage and human loss. There have been many mechanisms of injury described in the literature depending on the method of dissipation of energy. These include direct hit, contact voltage, splashing (side flashing), ground current (step voltage effect and surface arcing), and upward streamer[2].

The effects of lightning on individuals depend on the mechanism of energy transfer. In a review of 19 victims of lightning strikes, Lichtenberg *et al* found that patients with direct mechanism of injury are associated with more severe myocardial dysfunction and pericardial effusion compared to the effects of ground current generated by a nearby lightning strike. They also concluded that the dysfunction was reversible in his series within two weeks [3].

Cooper reported higher incidence of deaths among patients with lower limb and cranial burns in a study that examined 66 cases of lightning injuries. She also concluded that death was unlikely if there was no immediate cardiac arrest[4].

Similar cases have been reported in the literature showing that prolonged resuscitation was successful in managing the patients without major complications with emphasis on the importance of bystanders and paramedics in delivering life support [5]. In our experience, immediate and prolonged resuscitation efforts facilitated by automated defibrillators and public engagement in the process, resulted in a favourable outcome.

Most lightning injury incidents involve only one person but, in this incident, 3 people were injured by a single lightning flash. Exceptionally much larger groups of people have been injured by a single cloud-to-ground lightning discharge. One occurred when a thunderstorm interrupted an under-10-year-olds' football match in Kent, England, in September 1995. Four adults and 13 boys who took shelter under a tree were injured when the tree was struck by lightning and electric current affected them[6,7]. The largest group to be struck by lightning took place at Ascot horse race course, Berkshire, England, in July 1955 when 46 injured spectators had to be taken to local hospitals[8].

Injuries or fatalities caused directly by lightning are a rare occurrence in NI compared to the rest of the UK. NI experiences relatively few days of thunderstorms each year. The annual average 'number of days of thunder heard' is 5 to 9 days, similar to Scotland, Wales and most parts of Ireland, but much less than southern and eastern England which averages 15 to 19 days[9]. Annual average lightning flash density reflects this frequency with rates of less than 0.25 flashes per km^2 per year in NI compared to up to 1.00 flashes per km^2 in parts of England[10] (Figure 4).

Lightning injuries are uncommon in NI. TORRO's National Lightning Incidents Database lists 497 known lightning incidents causing injury or death to one or more persons in the UK during the past 30 years (1987-2016). This 30-year total updates the 25-year analyses of Elsom and Webb[11]. These incidents refer to injuries and deaths caused directly by lightning's electrical discharge. They exclude secondary causes of injury or death like fall or trauma. Of the 497 known

UK lightning injury incidents, 463 (93.2%) occurred in England and Wales, 27 (5.4%) in Scotland and only 7 (1.4%) in Northern Ireland.

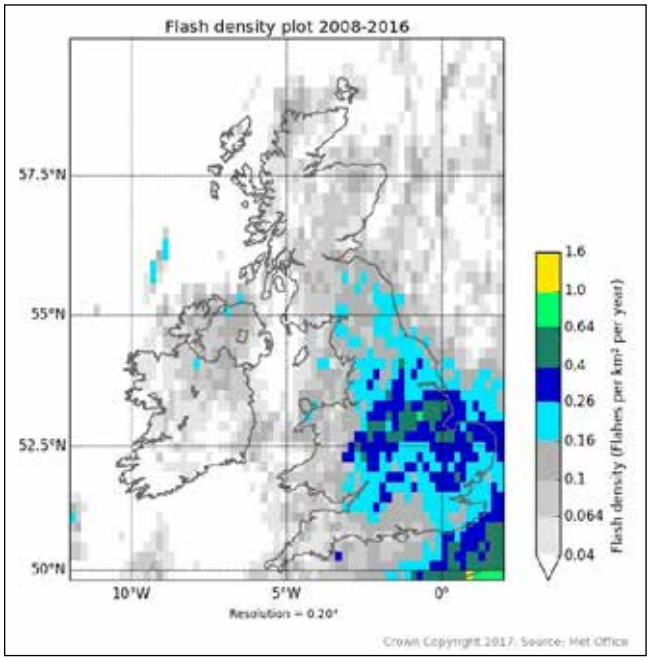

Fig 4. Lightning flash density for the UK, Ireland and surrounding areas highlighting that injuries and fatalities caused by lightning are likely to be relatively few in Northern Ireland compared with some parts of the UK. Maximum flash density (light green colour: up to 1.0 flashes per km^2 per year) is located in the English North Midlands. Data compiled from the Met Office Arrival Time Difference Network (ATDnet) lightning location system. Reproduced courtesy of the Met Office.

Lightning fatalities derived from death certificates in which lightning is the 'underlying cause of death' (currently code X33) have been reported by the Northern Ireland Statistics and Research Agency (Registrar General's Annual Report) since 1964. TORRO, the UK-based TOrnado and storm Research Organisation, complements the agency annual reports, by compiling its own National Lightning Incidents Database which provides more details about each fatality such as the date, type of location and activity being undertaken when struck by lightning. From 1964 to 2016, there have been 158 lightning fatalities in the UK with 144 deaths in England and Wales (91.1%), 11 deaths in Scotland (7.0%) and 3 deaths in Northern Ireland (1.9%). The three deaths in Northern Ireland occurred in 1970, 1982 and 2006 and all were male. The most recent death in April 2006 was an off-duty soldier struck on the Mourne Mountains[12]. This death was recorded in the agency annual records in 2007 because the Coroner's Inquest and the issuing of the final death certificate did not happen until May 2007[13].

Our hospital records failed to show more data about other patients struck by lightning as patients admitted in other health care trusts will be coded at the initial hospital before transfer to our unit.

This NI event involved people undertaking their 'daily routine' activity when struck by lightning: a parent collecting children from school. Elsom[14] and Elsom and Webb[13] analysed the incidence of lightning fatalities in the UK using three broad groups of activities being undertaken at the time they were struck: at work, undertaking the daily routine, and participating in leisure, recreation and sports activities. Around three-quarters of all fatalities in the past three decades were amongst people participating in leisure, recreation and sports activities. The remaining 30 per cent were split approximately equal between the other two activity categories. Jensenius[15] performed a similar analysis of USA lightning fatalities for the past decade and also found that people participating in leisure, recreation and sports activities accounted for the majority of fatalities. Lightning injuries are associated with a similar broad activity distribution[11]. In contrast, during and prior to the early twentieth century, lightning injuries and fatalities at work, especially amongst those working in agriculture, were far more common. For example, in the UK around the 1850s and 1900s, more than half of all lightning fatalities occurred while people were working and there were few fatalities amongst the smaller number of people engaged in leisure, recreation and sports activities[14].

The risk of injury from lightning may be reduced significantly by seeking shelter when thunderstorms develop. Safe shelters include a well-grounded, substantial building or a metal-topped, enclosed motor vehicle. Small structures (huts, sheds) are not safe as they are not usually electrically earthed. Nor is standing under a tree safe. If caught out in the open, adopting the 'lightning crouch' (crouch down, head tucked down, heels together, arms resting on your knees, and hands covering your ears) has been advocated as a 'last resort' by the Wilderness Medical Society (WMS) which provides lightning safety guidelines[1]. However, many believe this does not provide a significant level of protection from being injured or killed by a direct lightning strike. People on exposed hill or mountain slopes are advised that it is better to continue moving downhill to a safe shelter even though it may take some time to reach[16]. Lightning is more likely to strike hill peaks so descending to a lower altitude reduces the risk of being struck. If in a group, spreading out increases the chances for survivors who could come to the aid of any victims from a lightning strike.

In conclusion, while lightning injuries are rare in NI, this is the first report of more than one person affected by a single lightning incident in the province. In our limited experience, immediate public response and prolonged cardiopulmonary resuscitation was key to a favourable outcome.

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