THE COMMUNIQUÉS

VOLUME 10. ISSUE 4.
DECEMBER 2023 Edition
ISSN 2204 - 0099

Clinical Communiqué

Next Edition: March 2024

Editorial

Associate Professor Nicola Cunningham

Welcome to our fourth and final edition of the Clinical Communiqué for 2023. In this edition we feature a specific event and diagnosis that led to the tragic loss of ten lives. A cascade of moments that occurred over a short space of time, with an outcome that will be forever etched in the memories of patients, families, first responders, clinicians, and entire communities.

That event was the thunderstorm asthma phenomenon that took place in Melbourne, Australia on 21 November 2016. An unprecedented and catastrophic convergence of factors that triggered severe asthma symptoms in susceptible individuals on a level that overwhelmed emergency and health services.

Many Melbourne-based clinicians can recall the precise moment they learnt that something terrible was unfolding. I was overseas at an emergency medicine conference, along with many of my colleagues from Melbourne, and we woke on 22 November 2016 to hear that overnight our hospitals and friends back home had faced mass presentations unlike anything we had ever experienced before. As the coroner later noted, the twelve-hour period from 6.00pm on 21 November to 6.00am on 22 November 2016 saw the single greatest volume of calls for ambulance assistance received by the local Emergency Services Telecommunications Authority in its history. We felt helpless so many miles away, adding to the collective sense of dismay by those who had been 'on the ground' and contending with critical resource limitations as they responded to multiple calls for help.

There were many lessons to be learned from that single event. Government organisations and healthcare services looked at their state-wide responses. Clinicians reviewed their asthma management processes and researchers and meteorologists audited all the available data. The Coroners Court of Victoria continued this important work by acknowledging each of the patients that lost their lives in the event and highlighting the areas where there was potential for further improvement in public health and safety.

In this edition we present only one of those ten coroner's findings as a case précis in order to reflect on the key learnings from the coroner's inquest that was held to examine the ten deaths from the thunderstorm asthma event. We have also described the other nine patients' presentations as vignettes, in recognition of every person that lost their life in that event, and to demonstrate the critical aspect that was common to all of them – the terrifying rapidity with which their condition changed from being mildly short of breath to being in extremis. We must remember that it is a matter of minutes between life and death in thunderstorm asthma, and ensure we continue to build our frontline systems in a way that delivers the right care at the right time, every time.

We welcome a new author, Dr Kristin Boyle, an emergency physician, who skilfully articulates the chain of events and learnings as well as her own reflections in the case précis. Our expert commentary has been written by respiratory physicians Associate Professor Matthew Conron and Associate Professor Eve Denton. They brought their clinical expertise and research wisdom to our understanding of the event at the time, more recently in an article about the weather patterns experienced this Spring, and now with their illuminating contribution to this edition of the Clinical Communiqué.

CONTENTS

2. Editorial

3. **Case #1**
Something in the air

7. **More on the Matter**
In the blink of an eye

10. **Expert Commentary**
Thunderstorm asthma: what causes the "perfect storm"?

PUBLICATION TEAM

Editor-in-Chief:
Nicola Cunningham

Consultant Editors:
Joseph E Ibrahim
Brendan Morrissey

Designers:
Samuel Gillard
Paul Ikin

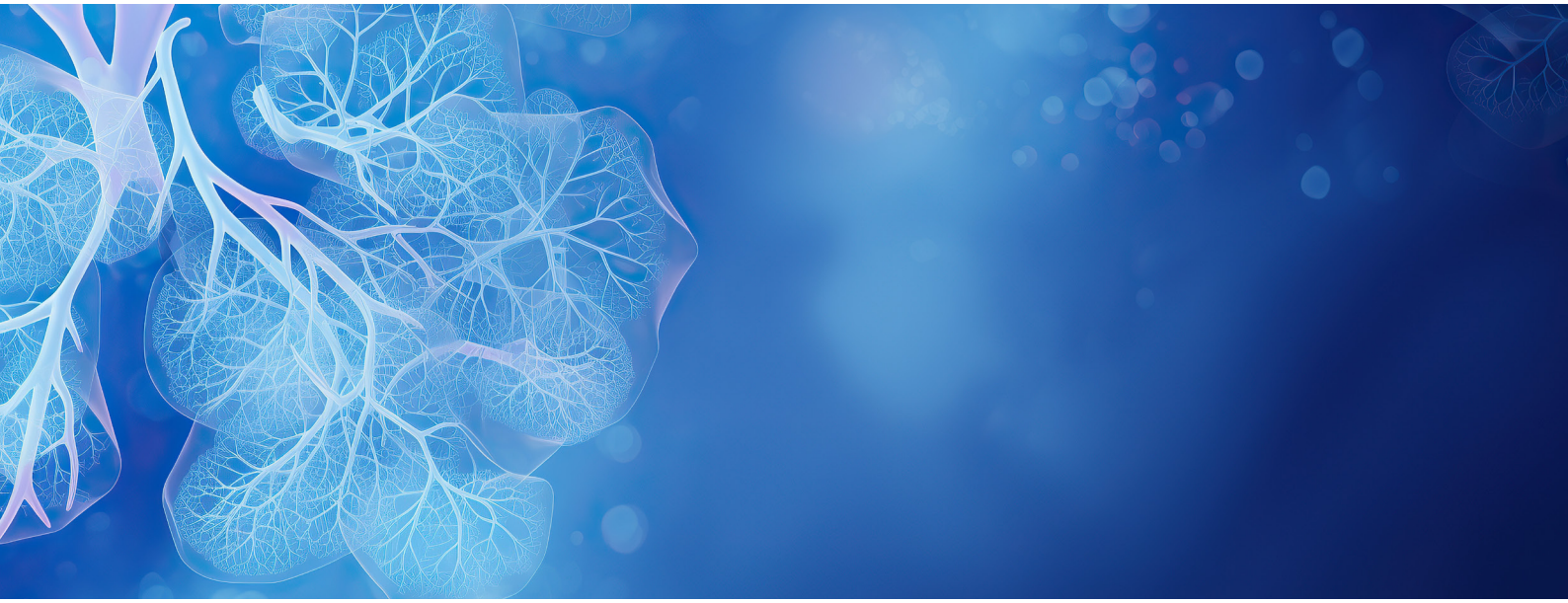
The Clinical Communiqué is distributed by the not for profit group 'The Communiques Australia Inc'.
(COI--A0106775D)

FREE SUBSCRIPTION

The Clinical Communiqué is published on a quarterly basis and sent electronically. Subscription is free of charge. Please register your email address at:
www.thecommuniques.com

FEEDBACK

The editorial team is keen to receive feedback about this communication especially in relation to changes in practice. Please contact us at:
cc@thecommuniques.com



Case #1 Something in the air

Case Number
COR 2016 5824 Vic

Case Précis Author
Dr Kristin Boyle
MBBS FACEM
Emergency Physician

i. Clinical Summary

Mr M was a 29-year-old married man living in regional Victoria. He was originally from China and had emigrated to Australia eight years prior. He had a history of asthma, hay fever, dermatitis, and food allergies. His asthma was noted to be worse during hay fever season, requiring the use of a reliever approximately twice weekly. He did not have a regular General Practitioner (GP), and there was no record of previous respiratory function or allergy testing.

Mr M first presented to his local regional emergency department (ED) around 20:00 hours on a weekday evening, giving a history of sudden onset severe shortness of breath and wheeze that had not improved with use of his salbutamol inhaler. He had a 'preventer' at home but was not currently using it, and there were no symptoms suggestive of a respiratory tract infection.

On examination, he was speaking in single-word sentences and using accessory muscles of respiration, with reduced breath sounds and widespread expiratory wheeze. His vital signs were: heart rate (HR) 126 beats per minute (bpm), respiratory rate (RR) 18 breaths per minute (/min), blood pressure (BP) 138/87mmHg, and oxygen saturations (Sa02) 97% room air (RA).

Unfortunately, Mr M was not alone in his presentation with respiratory symptoms that evening, and his management must be considered in this context. It had been a hot spring day, and as a late afternoon gusty thunderstorm swept across greater Melbourne, something very unusual was happening.

By 18:00 hours, an unprecedented number of triple zero calls were being received. Over the following hours, emergency services would be completely overwhelmed, and several young people would die. At the time of Mr M's presentation, the ED was initiating asthma treatment on patients sitting in chairs in corridors. The pharmacy would later run out of salbutamol.

While the cause was at that stage unknown, Melbourne and the surrounding regions were experiencing an environmental public health emergency, in the form of a globally unprecedented episodic thunderstorm asthma (ETSA) epidemic event.

Like dozens of other patients, Mr M was commenced on the departmental asthma protocol and treated with inhaled bronchodilators and oral prednisolone. By 22:50 hours his symptoms had resolved, and he was discharged home with a script for a salbutamol inhaler.

Mr M's next known contact with the health system was 17 days later, when he re-presented to the emergency department at 09:34 hours. On this occasion he reported onset of dyspnoea and difficulty speaking the previous evening. On examination he was speaking in full sentences and had a widespread wheeze. His vital signs were: HR 110bpm, RR 20/min, BP 134/90mmHg, and SaO2 96% RA. He was prescribed regular inhaled salbutamol and 50mg oral prednisolone and spent several hours in the ED and Short Stay Unit (SSU).

At 15:30 hours he was assessed by a doctor, just under an hour after his most recent dose of salbutamol. He had a mild residual wheeze but reported feeling improved. He was considered appropriate for discharge and given a script for oral prednisolone and a preventer inhaler. He was also advised to see a GP for ongoing treatment and development of an asthma action plan and to return to the ED if he experienced further symptoms.

Ten hours later, at 01:47 hours the next morning, a taxi driver approached the ED reception staff, asking for assistance with a passenger, and Mr M was found unresponsive in the front seat. On transfer to the resuscitation bay he was noted to be in asystole. Cardiopulmonary resuscitation (CPR) was commenced, and a code blue was called. Despite the correct placement of an endotracheal tube, the code blue team were not able to obtain an end-tidal capnography waveform.

At 02:41 hours Mr M's pupils were fixed and dilated, and his SaO2 levels were 19%, so a decision was made to cease resuscitation attempts and at 02:43 hours he was declared deceased.

ii. Pathology

Mr M's death was reportable due to being unexpected. Relevant post-mortem findings included bronchial haemorrhagic nucleoid material, no underlying cardiovascular disease, and no pulmonary embolism.

Specific weather conditions cause atmospheric pollen grains to swell and burst, and the resulting fragments are small enough to be inhaled deep into the airways, triggering a severe allergic asthma response in susceptible individuals.

His post-mortem toxicological analysis was also clear.

The medical cause of death was found to be acute asthma. Despite the temporal delay of 18 days between his first presentation to the ED and the terminal episode, the primary cause of the fatal asthma process was found to be the thunderstorm asthma event during which Mr M first presented.

iii. Investigation

Mr M's death was investigated by the coroner and heard at an inquest as a cluster of cases along with nine other deaths associated with the ETSA event. An expert opinion on thunderstorm asthma was provided by a respiratory physician and immunologist.

The scope of the coroner's investigation included:

- An exploration of the understanding of thunderstorm asthma prior to the event.
- The optimal clinical management of people with asthma and hay fever, both in general, and in anticipation of a ETSA event.
- The State's ability to predict and warn the general public of future ETSA events.
- The preparedness of emergency services for future surge events of a similar nature.

Importantly, given the extreme surge in demand on emergency and health services, the inquest focused on systemic issues and did not explore the adequacy of the individual clinical care provided to the deceased.

While the pathophysiology of thunderstorm asthma will be discussed in greater detail in the expert commentary, in essence, it is a rare coalescence of environmental, meteorological, and immunological processes. Specific weather conditions cause atmospheric pollen grains to swell and burst, and the resulting fragments are small enough to be inhaled deep into the airways, triggering a severe allergic asthma response in susceptible individuals.

A number of relevant government organisations had already conducted their own comprehensive inquiries. These included the Victorian Department of Health and Human Services (DHHS), Ambulance Victoria

(AV), the Emergency Services Telecommunications Authority (ESTA), who manage the triple zero emergency call system, and the Inspector General for Emergency Management (IGEM), an oversight body. To avoid unnecessary duplication where possible, the inquest process thus focused on reviewing the methodology and rigor of these inquiries, rather than a primary exploration of issues already addressed.

iv. Coroner's Findings

The coroner highlighted the globally unprecedented nature of the ETSA event. At the time the condition was essentially unknown within emergency services, with no real consideration of the potential public health impacts.

While there were no formal coronial recommendations, comments were made regarding the importance of further development of ETSA forecasting systems, and public awareness campaigns on the risks of thunderstorm asthma.

The coroner identified the highest risk factors for a severe episode of ETSA as pre-existing asthma, hay fever, and severe sensitisation to rye grass pollen. The cohort of deceased were also recognised to have several other features in common: All were young, the majority were male, and there was an over-representation of recent Asian immigrants. The majority were outdoors at some point during the event, and the use of preventers was generally sub-optimal. A number of mitigation strategies were thus suggested for higher-risk individuals, including seasonal use of a preventer, targeted allergy testing, and a pre-emptive plan of staying indoors and minimising exposure to outside air on predicted high risk days.

Regarding systemic issues, several common themes emerged.

Flexibility and ad hoc processes by emergency services in response to surge were commended, but agencies were still under-resourced to meet demand. Formal escalation pathways were not always followed, and inter-agency communication was often lacking.

The report acknowledged the extensive work done since the event in preparation for future ETSA or similar emergency events. For example, the implementation of real-time monitoring and notification of high-risk ETSA days, and the establishment of comprehensive thunderstorm asthma response plans by the Victorian Department of Health and Human Services, Ambulance Victoria, and the Emergency Services Telecommunications Authority.

One particular issue noted by the coroner at the inquest was the distress associated with being told "an ambulance is on its way", only for it never to arrive. The challenges with accurate forecasting of arrival times within the current system was acknowledged, and it was highlighted as an issue for further attention.

v. Author's Comments

As an emergency physician there are few things that cause me more trepidation than a young person with life-threatening asthma. A situation in which multiple young people present with life-threatening asthma would be one of those things.

One feature that stood out from the group of inquests was the rapid progression of this form of allergic asthma, in some cases from symptom onset to respiratory arrest in just under 15 minutes.

On reading the coroner's finding for Mr M, I was struck by just how many patients like him I have discharged over the years. One feature that stood out from the inquest was the rapid progression of this form of allergic asthma, in some cases from symptom onset to respiratory arrest in just under 15 minutes.

These patients are from a cohort in which many do not have a regular GP, and in the setting of a severe episode, might never make it to the ED. As emergency clinicians therefore, our greatest potential impact might just lie in prevention. That is, investing a little more thought regarding "the next episode" into a patient's asthma discharge process. Specifically enquiring about co-morbid hay fever and frequency of reliever use, commencing a preventer inhaler when clinically indicated, sending patients home with written action plans, and always encouraging them to seek engagement with a regular GP.

I had only been an emergency physician for a few months when this event occurred and suffice to say I will not forget the night; it felt like nature had decided to wage chemical warfare upon us. The day after, I debriefed with a GP friend. She had been preparing to leave her practice at the end of the day when a young man walked in off the street with severe dyspnoea and a silent chest. As they began emergency treatment another person walked in. Then another. The treatment room became a mini emergency department. A sole paramedic arrived, and apologetically informed them there would be no ambulances available in the foreseeable future, then stayed to assist with management. The same situation was replicated in GP clinics across the city. Many community pharmacies also stayed open late. This spontaneous primary care emergency response occurred in parallel to the formal emergency system, as emergency responders and healthcare staff skipped breaks and worked double shifts.

These communal acts of dedication and care, provided by people who worked tirelessly throughout the event, in response to an epidemic that none of us fully understood at the time, was aptly summed up during the coronial investigation by the Director of Emergency Operations for Ambulance Victoria:

"I've said it publicly, I think I'm right, I don't think I've seen so many lives saved on any given night."

To this, I must agree.

vi. Resources

The Victorian Government. The Chief Health Officer's Report: The November 2016 Victorian epidemic thunderstorm asthma event: an assessment of the health impacts. State of Victoria, DHHS, 27 April 2017. Available at: https://www.health.vic.gov.au/publications/the-november-2016-victorian-epidemic-thunderstorm-asthma-event-an-assessment-of-the.

National Asthma Council Australia. Thunderstorm asthma. National Asthma Council Australia, Melbourne: 2022. Available at: https://www.nationalasthma.org.au/living-with-asthma/resources/health-professionals/information-paper/thunderstorm-asthma.

Woodhead M. Hospitals overwhelmed with patients after "thunderstorm asthma" hits Melbourne. *BMJ* 2016; 355: i6391. Available at: https://www.bmj.com/content/355/bmj.i6391.

vii. Keywords

Thunderstorm asthma, allergy, epidemic, rye grass pollen, hay fever, emergency services

More on the Matter
In the blink of an eye

Dr Nicola Cunningham
B.Med, MForensMed, MHlth&MedLaw, FFCFM (RCPA), FACEM
Emergency Physician and Forensic Physician
Adjunct Associate Professor, Department of Forensic Medicine (Monash University)
Clinical Associate Professor, Department of Critical Care (University of Melbourne)

COR 2016 5536 Vic

Mr P was a 35 year old man who was diagnosed with asthma as a child. Through his teenage years he saw his GP for asthma flares which almost always occurred in the springtime, were triggered by hay fever, and managed with salbutamol, antihistamines and preventer medication. In the ten years prior to his death he had only seen his GP once for asthma. On 21 November he attended his outdoor work and was seen using his salbutamol puffer throughout the day. He began to feel unwell while driving home that evening, so he stopped into a friend's house and called his mother, asking her to meet him. When she arrived ten minutes later, he was leaning against his car, distressed, cyanosed and unable to speak. He collapsed as the ambulance arrived and CPR was commenced. He was transported to hospital, arriving there 50 minutes after the onset of cardiac arrest. He was unable to be resuscitated and was pronounced deceased at 20:16 hours, approximately 65 minutes after phoning his mother.

COR 2016 5542 Vic

Mr L was a 37 year old man with a childhood diagnosis of moderate to severe asthma. He had previously been treated with oral prednisolone and preventer inhaler medication for exacerbations that occurred mainly in winter. Work-related dust exposure was another asthma trigger and he used salbutamol approximately two to three times per week. His GP recorded a history of eczema and urticaria, and a diagnosis of obesity and obstructive sleep apnoea. His compliance with medical management was noted to be suboptimal.

On the evening of 21 November he was well, cleaned the house, and went to bed leaving the doors and windows open. He woke his wife at 04:40 hours asking her to drive him to her mother's house for salbutamol as he had run out. On the way, he was increasingly short of breath and became unconscious in the car shortly after their arrival. His family attempted CPR until the emergency services arrived.

The crew noted significant difficulties in extricating him from the car, and intubating and ventilating him at the scene. Despite another 30 minutes of resuscitation, there was no return of circulation and he was pronounced deceased at 05:53 hours, approximately 70 minutes after waking his wife.

COR 2016 5669 Vic

Mr H was a 49 year old previously well man who developed hay fever and asthma symptoms after emigrating to New Zealand and then Australia. His asthma was treated with salbutamol and inhaled preventer medication. On 21 November he saw his GP for symptoms of cough and wheeze. The GP prescribed an antibiotic, inhaled preventer medication and oral prednisone. He did not fill the prescription that day. On arriving home from school pick-up at 15:20 hours he felt unwell and went to lie down. Approximately three hours later he asked his wife to call for an ambulance. He then suffered a cardiac arrest and received CPR from a neighbour prior to the arrival of the ambulance at 19:10 hours. Ambulance officers achieved return of spontaneous circulation at approximately 19:40 hours and transported Mr H to hospital. He was admitted to the intensive care unit however repeated testing confirmed a severe hypoxic brain injury and eight days after admission a decision was made to withdraw treatment.

COR 2016 5534 Vic

Ms H was a 20 year old woman who was diagnosed with asthma at a very early age. She had a history of asthma-related admissions to the intensive care unit as a child. One of those admissions correlated with a previous Melbourne thunderstorm asthma event in November 2011. She used salbutamol and inhaled preventer medication regularly and over-the-counter antihistamines for hay fever. Rye grass pollen was a notable trigger for her asthma symptoms. On 21 November, Ms H did not appear to experience any asthma symptoms while at work but needed to use her salbutamol when she stepped out of her car after arriving home at 17:30 hours. The evaporative cooling was turned on, and she was coughing and using her salbutamol when her mother returned home at 18:15 hours. Her mother called an ambulance at 18:28 hours and Ms H went outside for fresh air while waiting for it to arrive. She collapsed suffering a respiratory arrest and CPR was commenced by her family and bystanders. The first ambulance was dispatched at 18:50 hours when the request was upgraded in priority for a cardiac arrest. The ambulance arrived at 19:03 hours and resuscitation efforts were continued by the paramedics, but were unsuccessful. She had died less than 120 minutes after arriving home.

COR 2017 0405 Vic

Mrs L was a 46 year old woman with a history of mild to moderate asthma, seasonal rhinitis and a possible food allergy. She was prescribed inhaled preventer medication and had a salbutamol puffer. She also used oral prednisone and salbutamol nebulisers on occasion and had filled her scripts for prednisone but not for her inhaled preventer medication in the past two years. On 21 November, she began to feel unwell at work at approximately 16:00 hours. She arrived home at 18:00 hours and she called out to her husband shortly after, complaining of difficulty breathing. After attempting to call an ambulance, Mrs L's family decided to drive her to hospital (which was approximately five minutes from their house). Enroute, she turned blue and was in cardiorespiratory arrest when they arrived at the emergency department at 18:53 hours, less than 60 minutes after calling out to her husband. Intubation by the emergency and anaesthetic teams was difficult and required several attempts. She was admitted to the intensive care unit but had sustained a severe hypoxic brain injury. She was transferred to the ward and received palliative care, dying approximately two months following the thunderstorm asthma event.

COR 2016 5542 Vic

Ms A was a 47 year old woman with a history of moderate to severe asthma and limited use of inhaled preventer medication. She also suffered from hay fever which often triggered her asthma symptoms. On 21 November at approximately 17:30 hours, Ms A was standing outside her house to look at her garden furniture. She returned indoors and left the windows open when the rain intensified. Just after 18:00 hours, she walked outside again, indicating to her husband that she was having difficulty breathing. He drove her about 100m to a nearby clinic, by which time she was unconscious, only a few minutes after she first indicated she was struggling to breathe.

Staff from the clinic assisted with resuscitation efforts in the car until the ambulance arrived at 18:42 hours. Cardiopulmonary resuscitation continued enroute to hospital and return of spontaneous circulation was achieved at 19:25 hours. She was admitted to the intensive care unit but developed multiorgan failure and a decision was made to withdraw treatment. She died four days later.

COR 2016 5616 Vic

Mr T was a 48 year old man who was fit and active. He was an ex-smoker and was previously prescribed Bretaris (aclidinium bromide, a long-acting, inhaled muscarinic antagonist used as maintenance treatment for chronic obstructive pulmonary disease). He was not known to have been treated with any asthma or allergy medications in the past. At approximately 18:00 hours on 21 November, Mr T was at home and appeared to be mildly short of breath with a light cough. The window was open at the time. Ten minutes later, he was markedly worse and asked his family to call an ambulance which they did immediately. He rapidly changed colour and stopped breathing and the family were instructed by the ESTA call-taker to commence CPR until emergency services arrived. The Metropolitan Fire Brigade arrived first at 19:40 hours and continued CPR until the paramedics arrived at 19:59 hours. There was return of spontaneous circulation, and he was transported to hospital where there were ongoing difficulties with ventilation. It was confirmed that he had suffered a severe hypoxic brain injury, and he died five days later.

COR 2016 5533 Vic

Mr O was an 18 year old man who was diagnosed with asthma at the age of four. He rarely used inhalers for his asthma but was troubled by hay fever, using antihistamine medications regularly. On 21 November, he spoke on the phone to his mother at approximately 17:15 hours and told her he had brought the garden furniture indoors as it was raining. He sounded normal to her at that stage. She returned home around 18:00 hours and found him using his inhalers and struggling to breathe so she drove him to a nearby clinic. When they arrived the clinic was full. A medical practitioner who was at the clinic for their own appointment overheard Mr O's mum asking the receptionist for help, and went to his assistance. Mr O was brought onto a bed and treated with oxygen, nebulised salbutamol and adrenaline. As clinic staff attended, he lost consciousness and suffered a seizure. The medical staff continued CPR until the ambulance arrived at 18:46 hours. He was unable to be resuscitated and pronounced deceased at 19:10 hours, approximately 70 minutes after first appearing unwell.

COR 2016 5671 Vic

Mr P was a 57 year old man with a past medical history that included asthma, diabetes mellitus, chronic obstructive airways disease, bladder cancer, hypertension, hay fever, and he was an ex-smoker. His asthma was thought to be well-controlled, and he used an inhaled preventer medication but less frequently than prescribed.

On 21 November, he was well during the day. At about 18:00 hours he removed laundry from the washing line and then moved his car into the garage because he heard it was forecast to hail. On returning inside, he told his wife he could not breathe and needed an ambulance. The triple zero call was made at 18:20 hours and the family were told an ambulance was on its way. They called again a short while later and were again informed that the ambulance was on its way.

Mr P collapsed around 18:30 hours, approximately thirty minutes after he first experienced symptoms, and his family commenced CPR and called for help once more. An ambulance was dispatched at 18:41 hours and arrived at 18:50 hours. Return of spontaneous circulation was achieved following a total down time of 50 minutes. Mr P was transported to hospital and admitted to the intensive care unit where he was diagnosed with a hypoxic brain injury. Active treatment was withdrawn eight days later, and he died later that day.

Thunderstorm asthma: what causes the “perfect storm”?

Associate Professor Eve Denton
MBBS, PhD, MPH, FRACP
Allergist, Respiratory and Sleep Physician
St Vincent’s Hospital Melbourne
Asthma, Immunology and Respiratory Medicine,
Alfred Hospital
Central Clinical School,
Monash University

and

Associate Professor Matthew Conron
MBBS (Hons), FRACP, MD
Director of Respiratory and Sleep Medicine
St Vincent’s Hospital Melbourne

Children are often scared of thunderstorms, a fear that most grow out of with time, but the thunderstorm and associated acute asthma outbreak that occurred in Melbourne on the evening of 21 November 2016 revived that fear of thunderstorms in many people. Not only in those who suffer asthma, but also those running health services, first responders and frontline clinical staff.

It has long been recognised that thunderstorms result in an increase in asthma symptoms. On that particular evening however, the atmospheric conditions aligned with a number of other factors to create the “perfect storm” resulting in the largest thunderstorm asthma outbreak ever reported, dwarfing all other previous events. Ambulance Victoria was swamped with more than 640 category one calls in under six hours. There was widespread inundation of health services across metropolitan Melbourne, a city of more than 5 million people, with patients experiencing life-threatening acute asthma attacks.

It is estimated that there were more than 13,000 presentations to emergency departments, and many more (the exact number is difficult to quantify) to primary health services and pharmacies.[1] In hospitals, patients were being treated in corridors and carparks as health services across the city struggled to deal with the sheer number and acuity of presentations. Many health services ran out of bronchodilator medication. Asthma-related admissions to hospital increased by nearly 1000% on that evening. There were a total of 35 patients admitted to intensive care units with asthma, and ten individuals died, the majority were young people who until a few hours before had been active and well.

Episodic Thunderstorm Asthma (ETSA) events are not a new phenomenon.

The first description of an outbreak of acute asthma was related to a thunderstorm in Birmingham in 1983, where it was thought that a rapid increase in airborne fungal spores, particularly Didymella exitalis and Sporobolomyces, led to an increase in asthma presentations.[2]

While ETSA events are a recognised phenomenon worldwide, there is one place that has seen more outbreaks than any other – the so-called allergy capital and thunderstorm asthma hotspot – Melbourne, Australia, where there have been seven previously recorded outbreaks, all occurring in the month of November.

Since that time, there have been outbreaks described in other parts of the United Kingdom including London; Australia, particularly in southern regional New South Wales; Atlanta, Georgia in the United States; in Athens, Greece; and in Ottawa and Ontario, Canada. One well-described event was an outbreak in London in 1994 when approximately 640 patients, mostly young people aged between 21 and 40 years, presented to emergency departments, with more than 100 admitted to hospital and five to intensive care.[3] Of these patients, two-thirds had a history of allergic rhinitis and for just under half this was their first ever asthma exacerbation.[3]

While ETSA events are a recognised phenomenon worldwide, there is one place that has seen more outbreaks than any other – the so-called allergy capital and thunderstorm asthma hotspot – Melbourne, Australia, where there have been seven previously recorded outbreaks, all occurring in the month of November. Furthermore, in addition to these reported events, retrospective analyses of emergency department data have identified spikes in asthma admissions (defined as a 4- to 5-fold increase in emergency presentations) occurring at times of rainfall and thunderstorms supporting the link between these local atmospheric conditions and ETSA.[4]

Clinical aspects of Episodic Thunderstorm Asthma events

So what is it about ETSA that makes it such an important condition to recognise and is it clinically different to other types of asthma exacerbations? Many of the emergency services personnel who were called out during the ETSA event in Melbourne in November 2016 understood immediately that the critical asthma presentations they were managing were different from others they had previously witnessed. On arrival to the scene ambulance workers were frequently faced with distressing scenes of whole households on their front lawns in respiratory distress. Many ambulance and emergency department staff described patients having an intractable dry cough to the point that they could not take a breath.

Later it was understood that this cough was the result of profound upper airway irritation caused by the extreme allergen levels in the atmosphere. This cough combined with lower airway bronchospasm added to the distress felt by the patients. Instead of staying inside with the windows shut to reduce allergen exposures, anxious individuals made their way outside where they received even more allergen exposure, compounding the problem.

Understanding the risk factors and clinical presentation of individuals with ETSA provides some clue about why this form of asthma has a high mortality rate and is such an important public health issue. Following the catastrophic ETSA event that occurred in Melbourne in 2016, a multidisciplinary collaboration of health care providers, meteorologists, public health experts and government agencies was brought together in an effort to better understand the risk factors and pathogenesis of ETSA and how this could inform clinical management and prevention of this condition.[1] Using a number of meteorological, health service and government databases, the largest ETSA cohort was described as being young (mean age 32 years), predominantly male (56%), being of Asian/Indian ethnicity (39% versus 24.8% of the general population based on 2016 census data), with 56% of the patients who presented to emergency departments having not previously been diagnosed with asthma.[1] Furthermore, of those with a known diagnosis of asthma presenting to hospital during this ETSA event, most were not on regular preventer therapy suggesting that many were previously considered to have mild asthma. Significantly, although the cohort of patients who were admitted to ICU (35 in total, 6 of whom died), all had a previous

diagnosis of asthma, only one-third were on regular preventer therapy, suggesting that even those with the most severe form of ETSA reflected the larger hospital population in that they were generally felt to have mild asthma prior to that admission.[5]

The observation that a high proportion of patients who presented during that ETSA event self-identified as being of Asian/Indian ethnicity is in keeping with the current understanding of the patient factors that contribute to the expression of this asthma phenotype. Conversely, being of Caucasian ethnicity, born in Australia, or having parents born in Australia was associated with a lower frequency of presentation to hospital.[6] This clinical observation supports the hypothesis that ETSA, like other forms of asthma is a condition resulting from exposure to environmental factors in genetically susceptible persons. It is well-recognised that lifestyle and environmental factors in western industrialised countries facilitate the development of atopy and asthma in migrants. Migrants appear to be more susceptible to the elaboration of atopic diseases than the indigenous population. It is likely that additional demographic, social, and economic factors contributed to the over-representation of patients of Asian/Indian ethnicity in the Melbourne 2016 ETSA cohort. For example, the rates of development of atopic diseases, in particular asthma and seasonal allergic rhinitis, is dependent on the age at the time of immigration.[7]

While language and cultural understanding are recognised barriers to accessing emergency services, other factors like new housing developments where migrants settle being located on the urban fringe where seasonal allergens are greatest might be equally important.

While many patients who develop ETSA do not have a previous diagnosis of asthma, many complain of symptoms of seasonal allergic rhinitis. In a telephone survey of nearly 1500 patients identified from emergency department records who presented during the Melbourne 2016 ETSA event, symptoms of allergic rhinitis were present in 87%.[8] It is likely that there is a proportion of the population that just experience upper airway rhinitis symptoms during thunderstorms associated with high pollen levels who do not seek medical assistance.

Given the high incidence of rhinitis in patients presenting to hospital, the presence of upper airway symptoms is a helpful clue in the identification of ETSA events. Eight of the ten patients who died of ETSA in Melbourne had a documented history of seasonal allergic rhinitis with all of these patients having an elevated IgE specific for rye grass, providing further evidence of the role of this allergen in the pathogenesis of this condition.[8,9]

Further studies have clarified additional risk factors for thunderstorm asthma; in those with suboptimal asthma control (impaired FEV1, higher eosinophils and fractional exhaled nitric oxide, or FeNO), and untreated asthma with low rates of inhaled corticosteroid use.[1,9]

Environmental aspects of Episodic Thunderstorm Asthma events

Thunderstorm asthma events arise due to the complex interaction between environmental and individual susceptibility factors. Environmental factors include a high concentration of an aeroallergen or in some cases fungal spores. In the case of the Melbourne outbreak the implicated aeroallergen was rye grass pollen (RGP), a grass pollen that is a common cause of seasonal allergic rhinitis in the Australian spring with a peak pollen count in November. Another factor is the presence of moisture. This moisture can cause rupture of these RGP particles releasing up to 700 allergen-bearing starch granules.[6] These fine allergen-bearing starch granules are respirable into the lower airways (unlike the larger unruptured pollen particles which tend to lodge in the nasopharynx causing allergic rhinitis) and have been demonstrated in vivo to cause asthma.[6]

Specific thunderstorm characteristics are important and contribute to the likelihood that a thunderstorm will cause asthma. Some of these characteristics that contribute to the risk include a rapid drop in temperature that sweeps larger pollen grains up into clouds where the presence of moisture then ruptures these grains into small particles.

A thunderstorm downdraft can then bring these particles back to ground level where tiny (2.5micron) particles can then be breathed into the small airways causing acute asthma.

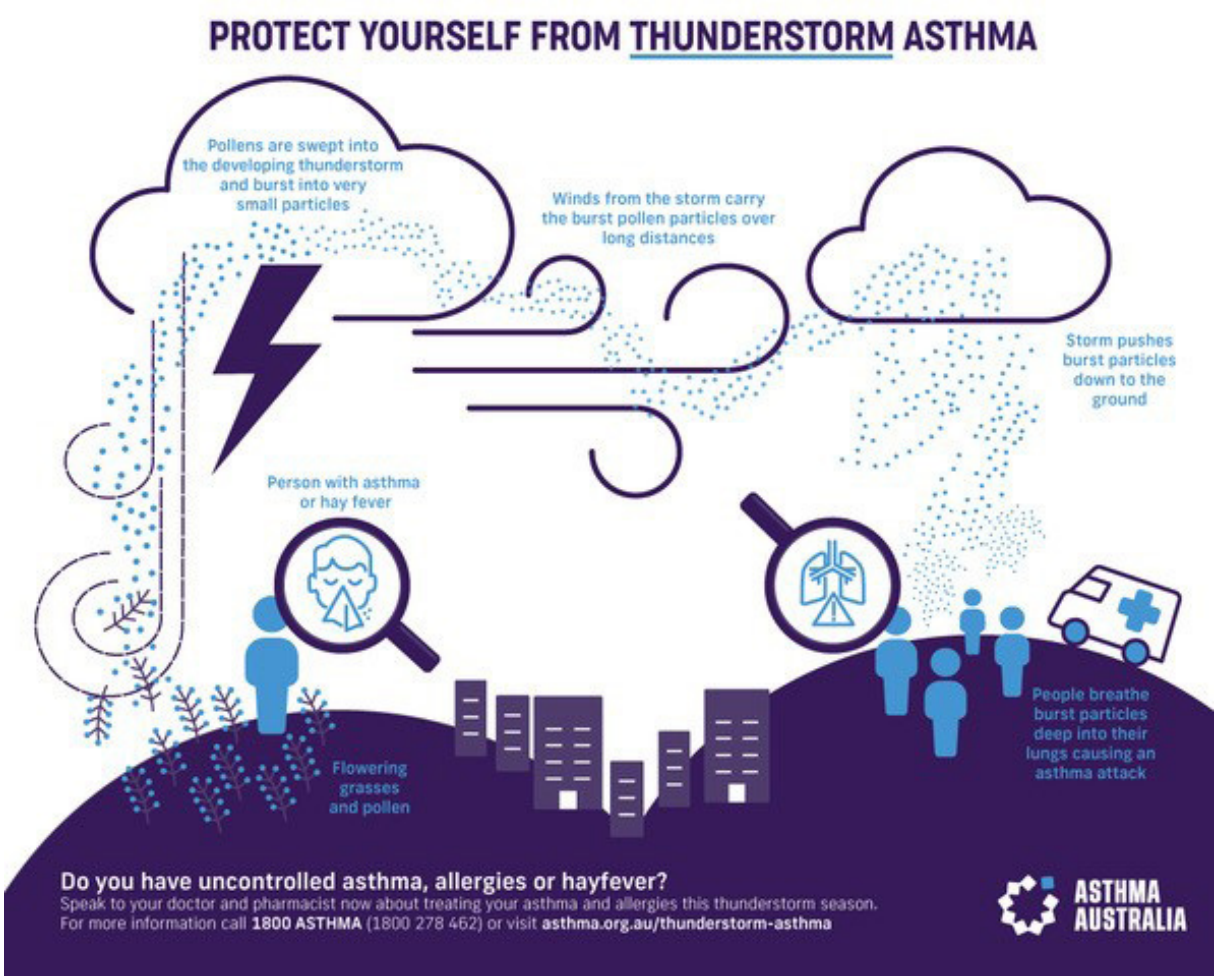


Image 1. How an Episodic Thunderstorm Asthma event occurs. Asthma Australia.
https://asthma.org.au/blog/tips-to-prepare-for-a-thunderstorm-asthma-event/

The presence of a thunderstorm outflow can continue to circulate these fine allergen-bearing granules at ground level causing ongoing exposure in individuals.[10]

Other environmental factors that have been shown to be important include the pollen exposure, particularly if individuals are outdoors or indoors with open windows.[5] This factor means that the time of day at which the event occurs is important – the Melbourne 2016 event occurred just before 6pm, a time when many people were travelling to and from work, maximising the population that was exposed to the ruptured pollen granules.

A similar event occurring overnight would likely have had less impact due to the majority of people being indoors at the time and therefore avoiding exposure.

Prevention and preparation for Thunderstorm Asthma events

Prevention

Recent work has identified that individuals at greatest risk of developing ETSA are: those with seasonal allergic rhinitis, raised eosinophils, elevated RGP specific IgE and lower lung function, a past history of thunderstorm asthma, and hospital presentation.[9]

Measures likely to be effective in preventing future ETSA events include education of medical professionals about commencing at-risk individuals on combination inhaled corticosteroids/long-acting beta2-agonists (ICS/LABA) therapy at the beginning of the pollen season. Adequate treatment of allergic rhinitis with intranasal steroids and antihistamines is recommended. There may be a role for rye grass immunotherapy in the prevention of ETSA. One study showed that those who were undergoing sublingual immunotherapy to grass pollen at the time of the 2016 Melbourne thunderstorm event were much less likely to require treatment for asthma or present to healthcare facilities than a matched group

who were not on immunotherapy, indirect evidence that it may play a role in prevention.[11] Individuals at risk of ETSA should have a written asthma management plan and be advised to reduce exposure on days of high pollen counts by staying inside, closing windows and if driving, putting the car air conditioner on recirculate. Government agencies can raise awareness of ETSA through public education campaigns and providing meteorological services that include information about pollen counts and forecasting ETSA events.

Preparation

Since the catastrophic thunderstorm asthma event in 2016, there has been a collaborative effort on the part of the Victorian Department of Health, and other government services and stakeholders to address systems issues that might improve outcomes for ETSA events. There is now more awareness of thunderstorm asthma and during the peak season, from late September to late December (but particularly November), there are regular media press releases to continue to raise awareness. Data from meteorological forecasts and pollen counts are combined to issue specific thunderstorm asthma warnings. Asthma sufferers and medical practitioners can access these warnings through the VicEmergency website (https://emergency.vic.gov.au/) or Mobile App. Public health messaging also encourages the use of pollen tracking Apps, and treatment of allergic rhinitis and seasonal asthma.

For emergency departments and other frontline clinical staff there is education and provision of additional supplies of bronchodilators during the high-risk period.

There has been implementation of a real-time Health Emergency Monitoring System that is designed to detect significant increases in demand on the public hospital emergency departments. Numerous symposiums and literature reviews have brought together experts to create comprehensive prevention and management guidelines that have been widely disseminated.

Unfortunately, due to the unique combination of factors that are required for a severe thunderstorm asthma outbreak to occur these events remain unpredictable. It is likely that these events will become more frequent with the increasing weather variability related to climate change.

It is important that there continues to be a cooperative effort between health and government services to reduce the impact and further improve the response to future thunderstorm asthma events.

Summary

The management of ETSA events involves prevention, treatment of acute cases - often in the context of stress placed on local health services due to a high case load, and addressing systems issues that improve emergency responses to natural disasters.

Despite the implementation of important prevention and management strategies as a result of the Melbourne 2016 thunderstorm asthma event, for many Melbournians – both thunderstorm asthma sufferers and those professionals that respond to these events – November thunderstorms are an ongoing source of disquiet.

Take home clinical messages

- To date there is little evidence to suggest that the medical management of acute episodes of ETSA should differ to the management of regular asthma episodes.
- ETSA occurs in susceptible individuals at specific times of the year depending on local allergen levels and atmospheric conditions.
- ETSA should be suspected in patients with seasonal allergic rhinitis or known sensitisation to rye grass who present with asthma symptoms.
- The absence of a previous asthma diagnosis should not discourage the diagnosis of ETSA.
- Incapacitating dry cough due to extreme allergen levels delivered to the upper airway is a prominent feature, as is a high mortality rate due in part to the severity of the bronchospasm but also the inevitable local case load that can overwhelm health services.

RESOURCES

1. Thien F, Beggs PJ, Csutoros, et al. The Melbourne epidemic thunderstorm asthma event 2016: an investigation of environmental triggers, effect on health services, and patient risk factors. *Lancet Planet Health 2018*; 2: e255-e263.

2. Packe GE, Ayres JG. Asthma outbreak during a thunderstorm. *Lancet 1985*; 326(8448): 199-204.

3. Davidson AC, Emberlin J, Cook AD, Venables KM. A major outbreak of asthma associated with a thunderstorm: experience of accident and emergency departments and patients' characteristics. Thames Regions Accident and Emergency Trainees Association. *BMJ* 1996; 312(7031): 601-604. doi: 10.1136/bmj.312.7031.601.

4. Silver JD, Sutherland MF, Johnston FH, et al. Seasonal asthma in Melbourne, Australia, and some observations on the occurrence of thunderstorm asthma and its predictability. *PLoS One* 2018; 13(4):e0194929. doi:10.1371/journal.pone.0194929

5. Lee J, Kronborg C, O'Hehir RE, Hew M. Who's at risk of thunderstorm asthma? The ryegrass pollen trifecta and lessons learnt from the Melbourne thunderstorm epidemic. *Respir Med* 2017; 132: 146-148. doi:10.1016/j.rmed.2017.10.012

6. Suphioglu C. Thunderstorm Asthma Due to Grass Pollen. *Int Arch Allergy Immunol* 1998;116(4): 253-260.

7. Rottem M, Szyper-Kravitz M, Shoenfeld Y. Atopy and asthma in migrants. *Int Arch Allergy Immunol* 2005; 136(2): 198-204. doi:10.1159/000083894

8. Hew M, Lee J, Susanto NH, et al. The 2016 Melbourne thunderstorm asthma epidemic: Risk factors for severe attacks requiring hospital admission. *Allergy* 2019; 74(1): 122-130. doi:10.1111/all.13609

9. Douglass JA, Lodge C, Chan S, et al. Thunderstorm asthma in seasonal allergic rhinitis: The TAISAR study. *J Allergy Clin Immunol*. 2022; 149(5): 1607-1616. doi:10.1016/j.jaci.2021.10.028

10. Marks GB, Colquhoun JR, Girgis ST, et al. Thunderstorm outflows preceding epidemics of asthma during spring and summer. *Thorax* 2001; 56(6): 468-471. doi:10.1136/thorax.56.6.468

11. O'Hehir RE, Varese NP, Deckert K, et al. Epidemic Thunderstorm Asthma Protection with Five-Grass Pollen Tablet Sublingual Immunotherapy: A Clinical Trial. *Am J Respir Crit Care Med* 2018; 198(1): 126-128. doi:10.1164/rccm.201711-2337LE

Acknowledgements

This initiative has been made possible by the voluntary contributions of the authors and editors in collaboration with 'The Communiques Australia Inc'.