DOI: 10.33470/2379-9536.1456

CASE REPORT Volume 10 Issue 4

# Industrial Explosion Survival After Presenting to a Rural Hospital: A Case Report

**Carol Wright Becker, MD[1], Roger D. Tilotson, MD[1], William Krantz, MD[1], Brad End, MD[1], Stephanie Rellick, PhD[1], Emily Nutter[1]**

## ABSTRACT

Explosions can lead to numerous injuries.[1] Studies show that trauma mortality increases by 14% when patients are treated at rural hospitals compared to non-rural facilities.[2] A 43-year-old male arrived at a rural hospital with injuries from an explosion, where only a single board-certified emergency physician was on duty. The patient's polytrauma was severe, resulting in bilateral orbital compartment syndrome and Cushing's triad. Remarkably, he survived these extensive injuries. Despite the limitations of rural healthcare, such as restricted equipment, medications, and longer transfer times, rural emergency physicians should remain optimistic and help guide future management. This high-acuity, low-frequency trauma case underscores the necessity for board-certified emergency physicians to be present in all emergency departments, including those in rural critical access hospitals. Rural emergency physicians should stay optimistic despite limitations in rural care, such as limited equipment, medications, and prolonged transfer times, and help guide future management. This unique case of high-acuity, low-frequency trauma presenting to a rural single-provider emergency department supports the need for emergency physicians to staff all emergency departments, including those in rural critical access hospitals.

*Author affiliations are listed at the end of this article.*

*Corresponding Author:*
Carol Wright Becker, MD
West Virginia University
caroldoctorwright@gmail.com

## KEYWORDS

explosion; rural; lateral canthotomy; Cushing's Triad; case report

## INTRODUCTION

Blast-related trauma may result in a combination of blunt and penetrating injuries.[1] Historically, in the United States, the likelihood of managing blast injuries is low outside of the combat environment.[1] Primary blast injuries occur from both the blast wave and the associated abrupt changes in atmospheric pressure. Secondary blast injuries occur when objects strike the patient. Tertiary blast injuries occur when the patient's body is propelled into a stationary object.[1]

Patients presenting to rural facilities compared to non-rural facilities for trauma have been shown to have 14% higher mortality.[2] Patients from rural environments also face an elevated risk of trauma compared to non-rural inhabitants.[2] In this case, the patient presented to a critical access hospital staffed with single-provider coverage, minimal resources, and no specialty services. However, emergency physicians (EPs) in these settings demonstrate remarkable resourcefulness despite these challenges. They must be prepared to perform procedures to intervene in life and limb-threatening injuries or illnesses, occasionally using improvised equipment or techniques due to limited resources and supplies.

## CASE REPORT

A 43-year-old male with no known past medical history was brought to a rural critical access hospital by ground ambulance after sustaining injuries secondary to an industrial explosion. The patient was working on an experimental process

of making charcoal from wood when there was an explosion, and he was thrown approximately 30 feet. On the primary survey, he was noted to have sonorous respirations, with a blood pressure of 118/79 millimeters of mercury (mmHg), heart rate of 104 beats per minute (bpm), and Glasgow Coma Score (GCS) of 8 (Eyes 1, Verbal 2, Motor 5). He was intubated for airway protection following standard rapid sequence induction.

Post-intubation vital signs included a blood pressure of 118/79 mmHg, heart rate of 104 bpm, respirations 13/minute, and oxygen saturation of 98% with administration of 100% FiO2 on initial ventilator parameters. His weight was 99.8 kg. An electrocardiogram was obtained after intubation, notable for sinus bradycardia with a rate of 56 beats per minute at regular intervals and no acute ischemic changes. Initial trauma radiographs of the chest and pelvis were negative. On the secondary survey, the patient was noted to have suffered extensive facial burns, singed nasal hair, and left-sided tympanic membrane rupture. He had numerous orthopedic injuries, including multiple metacarpal dislocations and bilateral ulnar and radial fractures. Neurologic examination was limited due to the patient's condition; however, he did exhibit purposeful movements on assessment of bilateral grip strength to verbal command. The patient was transported for computerized tomography (CT) after initial stabilization.

After initial stabilization and sending to CT while awaiting radiology read, further attention was directed at assessing his obvious ocular trauma. His pupils were unequal but reactive to light. He had significant periorbital edema, chemosis, subconjunctival hemorrhage, and a hyphema of the right eye. Intraocular pressure was measured using applanation tonometry (Tono-pen©, manufacturer), which revealed an intraocular pressure of 50 mmHg in the oculus dexter (OD) and 40 mmHg in the oculus sinister (OS) (normal range: 10-20 mmHg) consistent with Orbital Compartment Syndrome (OCS) bilaterally.[3,4,5,6] No retrobulbar hematoma was seen on either eye on the EP provider wet read. Due to these findings, the EP performed bilateral lateral canthotomies to prevent irreversible vision loss due to a combination of the patient's anatomy of significant periorbital edema and limited surgical equipment; a chest tube kit was used to obtain clamps of adequate length. The surgical equipment typically used was of insufficient length owing to the patient's significant periorbital and facial edema from trauma and burn. The EP completed the procedure using the longer-length instruments found within a chest tube tray to divide the canthal tendons. A repeat assessment of IOP following this procedure revealed improved pressures in both eyes (20 mmHg OD; 23 mmHg OS). He was noted to have improved proptosis, although he did exhibit lateral deviation OS (Figure 1).

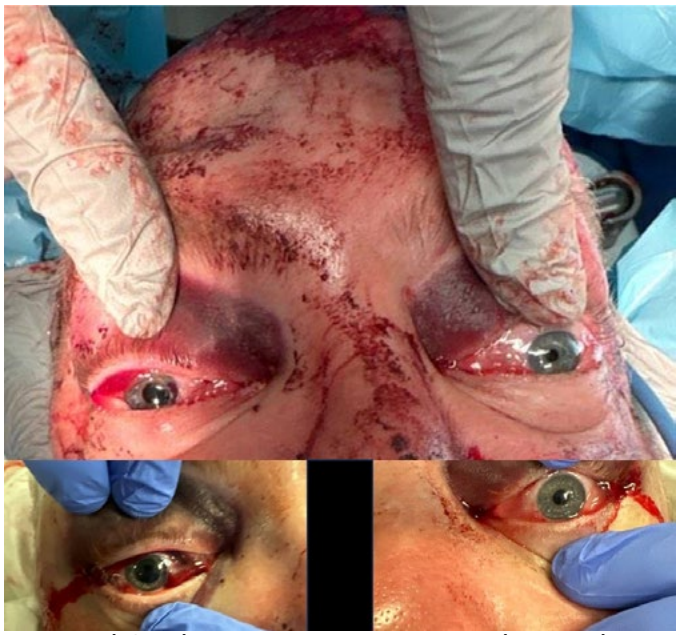

**FIGURE 1:** Pre and Post Lateral Canthotomy A: Eye exam. Initial exam showed lateral deviation in the left eye, and enlargement of the right pupil. B: Right and left eyes post lateral canthotomy

Initial CT brain/facial bones demonstrated a diffuse traumatic brain injury. His injuries included extra-axial hemorrhages with diffuse subarachnoid hemorrhage, bifrontal subdural hematomas, and a left frontal epidural hematoma. Additionally, the patient had a left frontal lobe intraparenchymal hematoma, extensive bifrontal hemorrhagic contusions, and probable diffuse axonal shear injury. Intracranial mass effect was minimal, with no evidence for transtentorial herniation and normal appearing ventricles. Extensive craniofacial fractures were present, most notably highly comminuted open bifrontal bone fractures with superior orbital wall blow-in versus blow-out fractures. There was direct continuity between the bilateral orbits and anterior cranial fossa. The patient had severe bilateral proptosis with both ocular globes projecting anterior to the interzygomatic line, with an estimated distance of 28 mm between the anterior margin of the ocular globes and the interzygomatic line (typically less than 21 mm)[6] (Figure 2).

While awaiting transfer to a tertiary facility that could manage burns and trauma, the patient was noted to exhibit hypertension to a systolic pressure of 220 mmHg and bradycardia with a rate of 30 bpm. These findings alerted the EP to consider the possibility of Cushing's triad owing to presumed elevated intracranial pressure (ICP).[7,8,9] He was manually hyperventilated and given 3% hypertonic saline bolus and Atropine with improved vital signs. He was started on a nicardipine infusion and loaded with levetiracetam and cefazolin. Tetanus toxoid was administered. Central venous access was obtained via the internal jugular approach, and a femoral arterial line was placed to permit invasive blood pressure monitoring.

Laboratory testing was obtained and was significant for mild leukocytosis (17.1k/uL) with normal hemoglobin, hematocrit, and platelet counts. His serum electrolytes were within normal limits, except for mild hypokalemia (2.7 mmol/L) and hyperglycemia (209 mg/dL). His international normalized ratio (INR) was standard (1.02). Serum ethanol was undetectable. He was placed into splints for his bilateral upper extremity orthopedic fractures and dislocations.

After a delay in transfer due to poor weather, the receiving facility conducted a follow-up CT of brain/facial bones approximately 6 hours later, which showed a significant worsening of extra-axial hemorrhages and intraparenchymal hematoma and contusions (Figure 3). Evidence for increasing intracranial mass effect was present, including developing left-sided uncal herniation and the presence of a suspected Duret hemorrhage, a midline midbrain collection of blood due to rapidly growing herniation. Lateral ventricles were

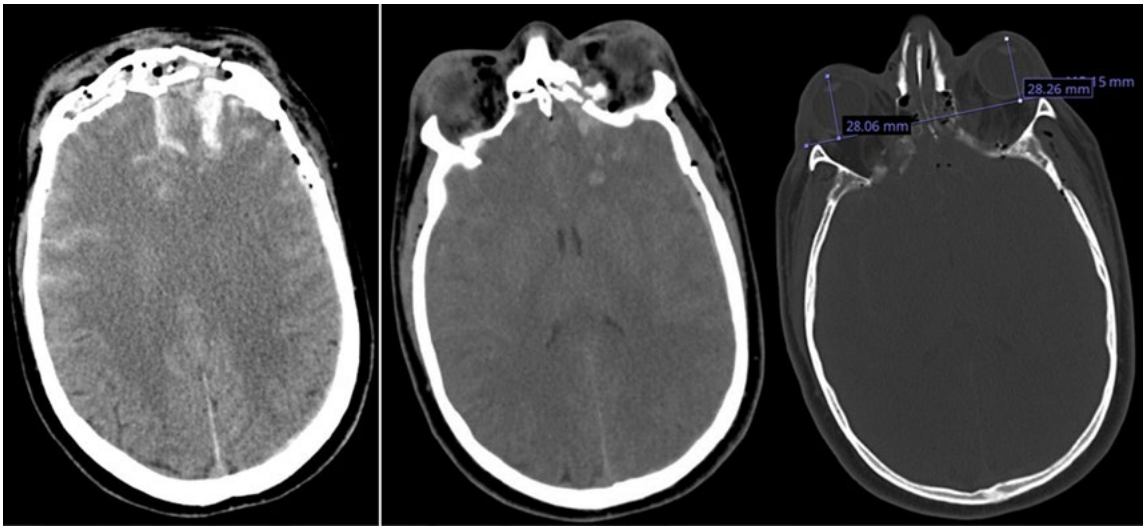


**FIGURE 2:** Extensive hemorrhage and open skull fracture and measurements of proptosis
Brain and skull windows on itnitial CT scans after arrival

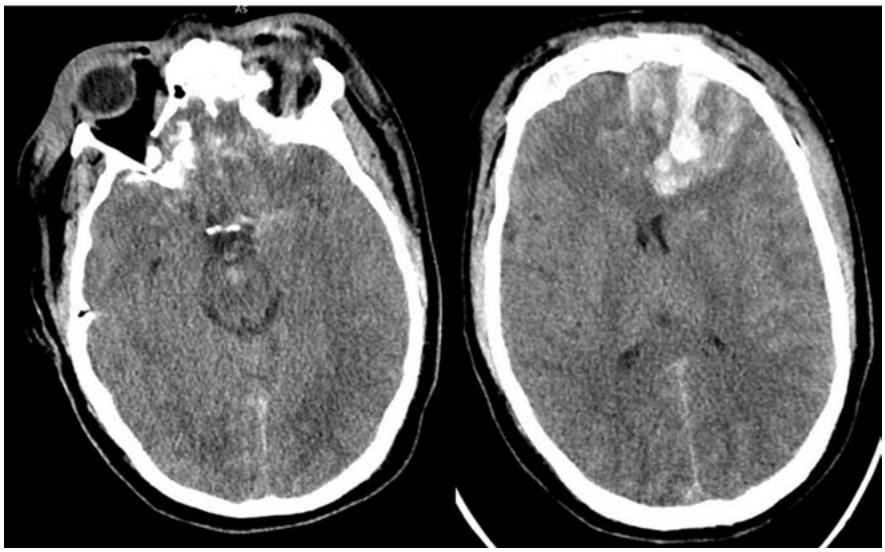

**FIGURE 3:** Progressive CT Scans. Worsening extra-axial hemorrhages and intraparenchmal hematoma and contusion with mass affect and left sided uncal herniation. (Left-initial scan; R- after transfer to higher level of care)

increasingly effaced. Craniofacial fractures were not significantly changed. Proptosis was again present unchanged.

## DISCUSSION

This case highlights several of the challenges of managing a critically ill polytrauma patient in a rural critical access hospital with limited resources. The authors aim to encourage rural providers to recognize and be willing to attempt similar procedures in a rural environment if a similar patient presents to their rural emergency department.

The utility and time-sensitive nature of recognizing OCS and its emergency treatment with lateral canthotomy has been described elsewhere in the trauma setting.[5] This unique case involved bilateral lateral canthotomy in a rural, critical access hospital with a single emergency department provider and no on-call surgical/ophthalmologic specialty coverage. In addition, the lack of traditionally appropriate surgical instruments with extensive facial edema precluding the use of a suture repair kit led to the EP's need to improvise with the use of a chest tube kit, which provided viable alternative equipment (scissors and clamps) to complete a successful lateral canthotomy. The instruments from a traditional suture kit were of insufficient length due to the degree of periorbital edema. In a rural emergency department, a provider must be resourceful when the tools available at a tertiary care center are unavailable.

Cushing's triad from elevations in ICP includes bradycardia, hypertension, and abnormal breathing.[8] In head trauma, elevation of the ICP requires an increase in mean arterial pressure to maintain cerebral perfusion pressure.[9] In this case, the initial CTs did not show signs of herniation; however, the repeat imaging at the tertiary care facility did have signs of uncal herniation. The clinical change in vital signs signaled a shift in clinical status after obtaining initial imaging. This case supports evidence that the vital signs change with increasing ICP as supported by the pathophysiology of Cushing's trade, given the initial CT and repeat CT showing no signs of herniation on repeat imaging showing signs of herniation.

Rural critical access hospitals frequently lack surgical sub-specialty coverage. However, this patient's injury pattern warranted emergent consultation with ophthalmology, otolaryngology, orthopedics, neurosurgery, and trauma surgery. Such patients are routinely transferred to a trauma center with such

coverage. In this case, there was an approximate 4.5-hour transport time to the closest trauma center, which was delayed even further due to weather. With the time-sensitive nature of OCS in mind, the EP correctly appreciated the need to perform a potentially vision-sparing lateral canthotomy before transfer. The goal of the emergency provider was to temporize the situation while awaiting transport. This builds on prior literature emphasizing the importance of knowing emergency procedures even in the austere environment.[10]

This case report builds on the known literature on trauma patients and rural healthcare. The patient suffered numerous traumatic injuries from the explosion, which is typical of such mechanisms.[1] Also, building on known literature, he had longer transport times coming from a rural facility than if he had presented to urban counterparts.[11] Given the delay in transfer, one could assume there may have been better outcomes if he presented to a tertiary care facility. This supports the idea that reducing essential differences between rural and urban settings is critical for patient care, especially trauma care in rural settings.[11] Additional studies are needed to help reduce discrepancies and improve equitability in rural facilities.[12]

After arrival at the tertiary center, the patient underwent bilateral frontal craniectomies. He survived his injuries. However, he did exhibit persistent neurologic impairment, requiring discharge to a rehabilitation facility. On follow-up ophthalmologic examination, he was noted to have persistent anisocoria and impairment of lateral gaze. However, his vision was fortunately preserved, and he can track items in the visual field. After initially presenting to a rural hospital with transfer delays, he was ultimately able to receive definitive care and survive his injuries.

## CONCLUSION

Explosions, orbital compartment syndrome, and severe craniofacial injuries are all unique medical entities, especially when presented to a critical access hospital. Orbital compartment syndrome is an ophthalmologic emergency that can lead to irreversible vision loss due to increased intraocular pressure. Consulting with ophthalmology, while ideal, is only sometimes possible. This patient's clinical deterioration from no signs of herniation to signs of herniation on repeat imaging would also traditionally trigger the involvement of neurosurgical colleagues. Being in single provider coverage without surgical backup does not negate the EP from attempting, as with this case, numerous time-intensive and critical interventions.

In this case, a significant delay in transferring the patient to a trauma center reinforced the importance of training emergency department physicians to perform lateral canthotomy procedures and resuscitations, even in sub-optimal conditions. The extensive craniofacial fractures, skull fractures, and polytrauma may discourage a provider who is treating a patient under similar circumstances from attempting to perform an advanced procedure such as a lateral canthotomy. However, this case report highlights the importance of such procedures even in austere environments. In 2024, according to the American Hospital Association, there are 6,120 hospitals in the US, and 1,810 of them are deemed rural community hospitals.[13] This case demonstrates the importance of a board-certified emergency physician and their skill in staffing each emergency department, particularly in rural environments lacking specialty services and consultations with only 1 provider and no backup.

## INFORMED CONSENT

Consent was obtained from the patient's next of kin.

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## AUTHOR AFFILIATIONS

1. West Virginia University, Morgantown, West Virginia

## REFERENCES


1. Wightman JM, Gladish SL. Explosions and blast injuries. Ann Emerg Med. 2001;37(6):664-678.
2. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: geographic disparities in trauma mortality. Surgery. 2016;160(6):1551-1559.
3. Rowh AD, Ufberg JW, Chan TC, Vilke GM, Harrigan RA. Lateral canthotomy and cantholysis: emergency management of orbital compartment syndrome. J Emerg Med. 2015 Mar;48(3):325-30. doi: 10.1016/j.jemermed.2014.11.002. Epub 2014 Dec 16. PMID: 25524455.
4. Goodall KL, Brahma A, Bates A, Leatherbarrow B. Lateral canthotomy and inferior cantholysis: an effective method of urgent orbital decompression for sight-threatening acute retrobulbar hemorrhage. Injury. 1999;30(7): 485–490. https://doi.org/10.1016/s0020-1383(99)00137-0
5. Murgatroyd H, Bembridge J. Intraocular pressure. BJA Education. 2008 June;8(3):100–103, https://doi.org/10.1093/bjaceaccp/mkn015
6. Dähnert WF. Radiology Review Manual. 7th ed. Lippincott Williams & Wilkins; 2011.
7. Sun MT, Chan WO, Selva D. Traumatic orbital compartment syndrome: the importance of the lateral canthomy and cantholysis. Emerg Med Australa. 2014;26(3):274–278. https://doi.org/10.1111/1742-6723.12236
8. Cushing H. The blood pressure reaction of acute cerebral compression, illustrated by cases of intracranial hemorrhage. Am J Sci. 1903 June;125:1017-1044.
9. Dinallo S, Waseem M. Cushing reflex. In StatPearls [Internet]. 2023. StatPearls Publishing. https://www.statpearls.com/
10. Farber SJ, Kantar RS, Rodriguez ED. Facial Trauma Care in the Austere Environment. J Spec Oper Med. 2018;18(3):62–66. https://doi.org/10.55460/ZZN2-AT3U
11. Alanazy ARM. Wark S, Fraser J, Nagle A. Factors impacting patient outcomes associated with the use of emergency medical services operating in urban versus rural areas: A systematic review. Int J Environ Res Public Health. 2019;16(10):1728.
12. Morgan JM, Calleja P. Emergency trauma care in rural and remote settings: Challenges and patient outcomes. Int Emerg Nurs. 2020;51:100880.
13. American Hospital Association. Fast Facts on U.S. Hospitals, 2024. January 2024. Accessed October 18, 2024. https://www.aha.org/statistics/fast-facts-us-hospitals