

OUT-OF-HOSPITAL CHEST ESCHAROTOMY: A CASE SERIES AND PROCEDURE REVIEW

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ABSTRACT

Initial care for the burned trauma patient focuses on the rapid assessment and stabilization of airway, breathing, and circulation. Circumferential chest burns may restrict respiratory effort and inhibit adequate ventilation. When this occurs, chest escharotomy is the recommended treatment to restore chest expansion and therefore ventilation. Emergency medical services (EMS) providers infrequently encounter patients with circumferential chest burns, and escharotomy is generally not included in their scope of practice. The authors could not locate any documentation of other escharotomies performed in the out-of-hospital setting. This case series describes the care of two patients that required out-of-hospital chest escharotomy by physician members of a helicopter medical crew. The procedures of chest and neck escharotomies are reviewed, and the logistics of performing escharotomy in the prehospital setting are described. **Key words:** escharotomy; emergency medical services; prehospital; burn injury

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INTRODUCTION

This case series describes the care of two patients, involved in separate burn incidents between the years 1992 and 2007, who had emergent chest escharotomy in the field by physicians staffing a civilian rotary-wing air ambulance. Emergency chest escharotomy is a potentially lifesaving procedure for circumferential chest burns. Chest escharotomy is generally not included as a skill within the scope of practice of emergency medical services (EMS) providers, and the authors could not find any other reports of this procedure in the out-of-hospital setting by health care providers.

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Case 1

Response

A 41-year-old woman suffered self-inflicted thermal burns after wrapping herself in a blanket in an enclosed space and then lighting the blanket. A local basic life support ambulance and advanced life support squad were dispatched, and later an air ambulance was requested. The air ambulance crew included a flight nurse and a flight physician. The flight physician was an emergency medicine resident in the second postgraduate year (PGY2) of training.

Prior to EMS arrival, the fire had been extinguished with buckets of water.

Patient Assessment

Upon arrival of local EMS, the patient was found to have extensive burns. The majority of the burned surface was taut and leathery, and she was estimated to have third-degree burns to at least 90% of her body surface area (BSA), with partial-thickness burns to small sections of her forearms and sparing of any burns to the soles of her feet. The patient was awake and speaking softly in a whisper, but she had respiratory distress and had poor chest wall expansion. She had circumferential chest, neck, and face burns that left the skin taut and leathery. In addition to restricting her chest wall expansion, the leathery burns of her face significantly diminished the ability to open her mouth and move her neck.

Emergency Medical Services Treatment

Ground EMS treatment included insertion of a peripheral intravenous (IV) line in the web space of the dorsal hand with infusion of normal saline solution (NSS) and the administration of high-flow supplemental oxygen. The flight crew prepared for cricothyrotomy, but first attempted intubation using rapid-sequence intubation (RSI) with midazolam (5 mg IV) and succinylcholine (100 mg IV). As anticipated by the restricted jaw and neck mobility, attempts at endotracheal intubation by direct laryngoscopy failed twice. An airway was subsequently and immediately established by open surgical cricothyrotomy without difficulty or complication. A 6.0-mm endotracheal tube (ETT) was inserted through the cricothyrotomy, and the patient was ventilated with a bag-valve-mask (BVM). This case preceded the use of capnography in the prehospital

setting. The circumferential chest wall had full-thickness burns and the skin was taut and noncompliant. Chest excursion was inadequate with manual ventilation attempts by BVM via the cricothyrotomy, so a chest escharotomy was performed. A No. 10 scalpel blade was used to make two longitudinal eschar incisions to each anterior axillary line from clavicle to costal margin bilaterally, with immediate improvement in chest wall expansion and ability to manually ventilate the patient.

The patient's heart rate remained tachycardic between 150 and 180 beats/min, and blood pressure could not be obtained because of the burns. The patient was given vecuronium (10 mg IV) after escharotomy. The patient was "packaged" for transport to the closest level I trauma center, where she had additional fluid resuscitation and completion of escharotomies to the neck and upper and lower extremities. Her arterial blood gas (ABG) results on arrival confirmed adequate ventilation (pH 7.36, partial pressure of carbon dioxide [pCO₂] 37 mmHg, partial pressure of oxygen [pO₂] 157 mmHg, and carboxyhemoglobin 2.5%). She was then transferred to a burn center, where she died several days later. The air ambulance response time from dispatch to landing on scene was 24 minutes, the on-scene time was 36 minutes, and the transport time was 9 minutes. The on-scene time was delayed because the aircraft was unable to land in the proximity of the patient.

Case 2

Response

An advanced life support ambulance and local fire department were dispatched to the scene of a burn victim. The victim had an accident near a campfire, but no further description of the mechanism was available. The local EMS personnel requested an air ambulance for transport to a distant burn center. The air ambulance was staffed with a flight nurse, flight paramedic, and flight physician. The flight physician was a PGY2 emergency medicine resident.

Patient Assessment

The patient was a middle-aged man who was unable to speak because of injuries. The exact time and circumstances of injury were not known, and the patient's past medical history was not available. He was agitated, restless, and combative for local ground EMS personnel. On initial assessment, the patient had suffered severe full- and partial-thickness burns involving approximately 96% of his BSA, sparing only his feet and ankles.

Emergency Medical Services Treatment

Treatment by ground EMS personnel included placement of an oral airway and ventilation by BVM with supplemental oxygen, intraosseous (IO) line placement with wide-open NSS infusion, spinal immobilization, and administration of midazolam (10 mg IO) for sedation before an unsuccessful initial attempt at endotracheal intubation.

The patient's condition deteriorated, and by the time the air medical crew met the patient in the ambulance, he had become unresponsive and was being ventilated via BVM. The flight crew performed RSI using succinylcholine (160 mg IO) and etomidate (30 mg IO), and the patient was intubated, without complication, by the flight crew on their second attempt. Prior to intubation, carbonaceous secretions were suctioned from the upper airway, and the intubator recorded swelling to the epiglottis and vocal cords. ETT placement was confirmed with waveform capnography, the absence of gastric sounds, and the presence of bilateral breath sounds. After intubation, there was no visible movement of the chest wall with ventilation, despite confirmed correct placement of the ETT. Because of the patient's circumferential chest burn, the crew decided to proceed with an emergency chest escharotomy. The physician performed the escharotomy using a scalpel by making five longitudinal skin incisions to the anterior chest. There was a dramatic improvement in chest wall expansion with continued manual ventilation.

The patient was wrapped in a heat-conserving space blanket and "packaged" for air medical transport. During transport additional vascular access was established with a peripheral IV infusion of wide-open NSS, and the patient was given vecuronium and midazolam. Heart rate ranged from 60 to 80 beats/min during the flight, but blood pressure and oxygen saturation could not be quantified because of the patient's extremity burns. The patient was transported to the closest burn center, where he subsequently died later that day. Clinical patient information was not available from the burn center. The air ambulance response time was 24 minutes from receipt of the call to arrival at the patient's side, the on-scene time was 13 minutes, and the transport time was 38 minutes.

DISCUSSION

History and Pathophysiology

Wallace alluded to the procedure of escharotomy in 1955 when, as part of his description of pressure effects and edema related to burns, he suggested that burn patients need nursing observation and "incisions."¹ In 1958, Bennett and Lewis described procedures to decompress the tourniquet effect of extremity burns, but they also mentioned the procedure of chest escharotomy.² In 1960, Wilson and Stirman

further described the need for chest escharotomy in treating the restrictions on respiration from the “inelastic girdle of burned skin” associated with circumferential chest burns.³

Burned skin leads to interstitial edema that compresses underlying soft tissues.⁴ When the burns are circumferential, this developing pressure can lead to ischemia when involving the extremities, elevated intra-abdominal pressures and ischemic bowel when involving the abdomen,^{5,6} tracheal and jugular venous compression when involving the neck, and respiratory compromise when involving the chest. Circumferential chest burns are associated with restriction of chest wall motion, leading to shallow respiratory excursions, low tidal volume, and retention of carbon dioxide.³ Escharotomy for extremity and abdominal compartment syndromes is an ongoing process of surgical decompression based on ongoing patient assessment,⁷ but escharotomy of the chest, and possibly neck, is more urgent, and therefore has indications in the prehospital and resuscitative management of burns.

Chest escharotomy decompresses the restriction on chest wall expansion and also assists in decompressing intra-abdominal hypertension. In a study by Tsoutsos et al. chest and abdominal escharotomies significantly decreased intra-abdominal pressure, retention of carbon dioxide, and central venous and inferior vena caval pressures while significantly increasing serum oxygen concentration and systolic blood pressure.⁸ While there are no studies of patient outcomes after emergent chest escharotomy, it is presumed that the physiologic changes from this procedure are potentially lifesaving in this patient group that already has a very high mortality rate.

Demographics

Thermal burns are an important cause of morbidity and mortality. The American Burn Association estimates that 500,000 burn injuries are brought to medical attention annually.⁹ The United States Fire Administration estimates that burns account for more than 3,000 deaths in the civilian population annually.¹⁰

Although burn injuries are common and severe burns are occasionally encountered by EMS and emergency department personnel, the need for emergent chest escharotomy is rare. Pruitt et al. described the need for one neck and eight chest escharotomies in 125 patients seen between 1965 and 1966,¹¹ and Burd et al. reported 12 chest/abdominal and 55 limb escharotomies in 118 seriously burned patients admitted to an intensive care unit (ICU) over five years. This group reported that there were issues with the timing or procedural technique in 37% of the escharotomies that were performed, but they did not specify the concerns related to chest escharotomy.⁷ In a review of 39 patients who had burns of at least

60% of their BSA, O'Mara et al. reported a mortality of over 80%, and the mortality was higher in those patients who required any escharotomy.¹² Lastly, in a report of a mass-casualty burn event related to an explosion, Tekin et al. reviewed 15 patients with burns ranging from 6% to 99% of their BSA. Six of these patients had burns of over 80% of their BSA, six died, and six required escharotomy.¹³ Although chest escharotomy is taught as a potentially lifesaving procedure in the care of patients with severe burns, there is little information on the success of this procedure in salvaging these severely injured patients, but clearly the need for escharotomy in severe burn cases carries an extremely high rate of mortality.

Treat et al. described the treatment and interfacility transport of 148 patients, during one year, to their burn unit by a specialized air transport team that included a surgeon and an intensive care nurse. Nine of these patients had escharotomies, six of which were either done by or revised by the surgical flight team, and these were all done within the hospital setting at the referring institution. Their series included two chest escharotomies, but the authors did not report whether these two were done by the flight crew or hospital staff.¹⁴

While burns are commonly encountered by EMS personnel, these demographic reports show that chest escharotomy is a relatively uncommon procedure, even by specialized burn teams and within burn centers.

Procedural Technique

Escharotomy is a relatively simple surgical procedure involving an incision through a skin eschar to the depth of the subcutaneous fat. This superficial incision permits expansion of the subcutaneous tissue and decompression of the underlying compartments. In the case of a circumferential chest wall burn, this expansion and decompression improve the decreased compliance associated with the restriction related to the burn.¹⁵

While escharotomies may be performed on multiple body parts, including the extremities, the digits, the chest, the abdomen, the neck, and the penis, it is escharotomy of the chest that is most likely to be indicated on an emergent basis in the out-of-hospital setting. When performed properly, escharotomy of the chest may cause a rapid and dramatic improvement in respiratory mechanics.

Several chest escharotomy incision techniques have been described. These include the following:

- bilateral longitudinal incisions in both anterior-axillary lines from the clavicles to the costal margins.^{3,15}

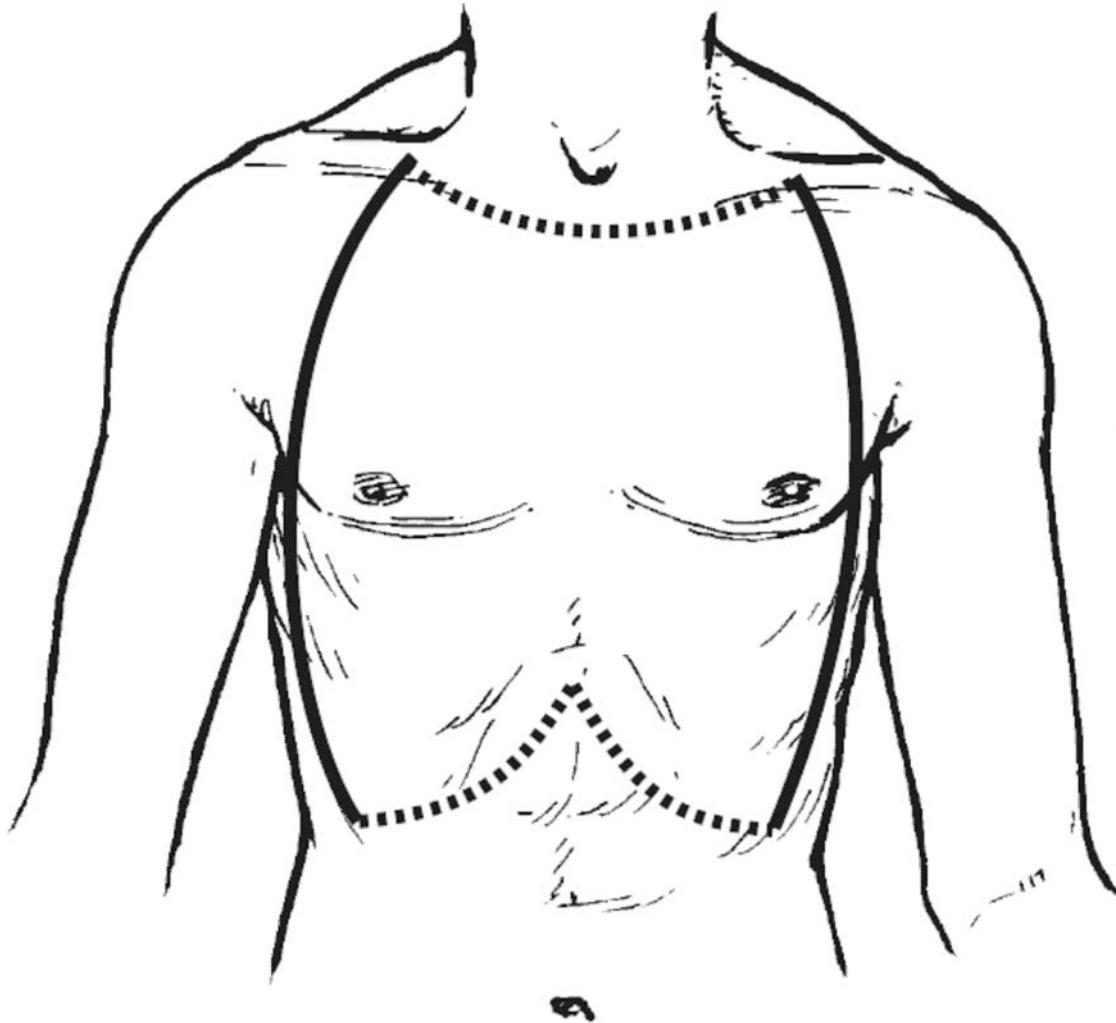


FIGURE 1. Suggested incision locations for chest escharotomy.

- a box pattern that includes bilateral longitudinal lines in the anterior-axillary lines connected by transverse incisions in both the superior and inferior anterior chest walls.^{16,17} Burd et al. refine this technique to suggest that the inferior transverse incision should follow both costal margins—meeting at the xiphoid area—to functionally separate the chest from the abdomen to allow for better chest wall movement⁷ (Fig. 1).
- a cross-hatched pattern.¹⁸

Because normal chest wall excursion is related to the forward and cephalad movement of the rib cage—sometimes described as lifting a bucket handle—there is no need to perform any posterior incisions as part of a chest escharotomy. With all techniques, it is important to avoid areas of breast tissue in female patients, including prepubertal female patients.¹⁷

Although not related to these cases of chest escharotomies, neck escharotomy is another procedure that may be of benefit emergently in the out-of-hospital

setting. This is indicated if the compartment syndrome associated with circumferential neck burns leads to compression of the trachea or signs of cerebral asphyxia due to compression of the great blood vessels in the neck. Authors on the topic have varying opinions. It has been suggested that neck eschar alone does not cause respiratory difficulties, but it has also been suggested that neck escharotomy may avoid unnecessary tracheostomy.¹¹ Neck escharotomy is a relatively simple procedure that involves an incision of the skin eschar longitudinally in the anterior midline from the chin to the sternal notch.^{16,17}

Logistic Issues for Emergency Medical Services

While chest escharotomy is a relatively uncommon procedure, these cases illustrate that under appropriate circumstances, the procedure can be performed before arrival to a hospital or dedicated burn center. While burn injuries are relatively common, chest

burns that may benefit from out-of-hospital chest escharotomy are extremely rare. In the 29 years of operation for this busy helicopter EMS system, out-of-hospital chest escharotomy has been performed only twice—the two cases discussed in this series.

Of note, neither physician who performed the escharotomies reviewed in this case series had ever performed or observed an escharotomy prior to these cases. In addition, both of the escharotomies performed on these patients utilized only vertical incisions, but were still able to relieve chest wall tension to an extent that provided adequate ventilation.

Scope of Practice Issues

States do not generally include the procedure of chest escharotomy within the scope of practice for nonphysician advanced life support EMS providers, nor is it generally included in EMS textbooks or paramedic education programs. In fact, EMS textbooks usually fail to mention chest escharotomy or specifically mention the procedure as an “in-hospital” procedure.¹⁹ Some states have provisions for exceeding scope of practice of EMS personnel in extraordinary situations when there is direct medical oversight by an online physician, while others either do not address these “heroic” circumstances or simply do not allow any practice that exceeds the scope of practice of EMS personnel within the state.

Chest escharotomy is technically a relatively simple surgical technique that requires minimal equipment. When done correctly, the incisions are superficial and the rib cage protects deeper and vital structures from injury. It can be argued that as a technical skill, a chest escharotomy requires less skill and has a lower risk of complication than does the procedure of cricothyrotomy, which is an uncommon procedure that is within the scope of practice of paramedics in many states. While risks of bleeding and infection are present with any procedure that violates the integrity of the skin, they are a secondary concern to ensuring adequate ventilation. As with most advanced procedures in EMS, clinical judgment, discretion, and decision-making skills are probably more important than the procedural technique when discussing escharotomy by EMS personnel. Escharotomy of body areas other than the chest, and possibly the neck, are not as time-dependent and are not indicated in the out-of-hospital setting.

Use of Air Medical Transport

With few exceptions, where airway or respiratory function are compromised and cannot be managed by EMS providers, the treatment of severe burns is not critically time-sensitive and ground transport to a burn center is usually appropriate. Baack et al. suggested that helicopter transport of burn patients was not med-

ically indicated for patients who were less than 180 miles from the burn center unless 1) the burn area was large enough for formal fluid resuscitation, 2) there was inhalation injury, or 3) there was a possible need for escharotomy.²⁰

Education and Training

Although not part of routine training, EMS systems that foresee allowing emergency chest escharotomy by EMS personnel, if permitted within the provider’s scope of practice, should consider methods to train personnel in this procedure. In addition to didactic education, Ali et al. described an innovative, simple, low-cost escharotomy task trainer that is targeted to developing countries because of its simplicity and low cost, but it could be equally useful as a task trainer for EMS systems and EMS education programs.²¹ Also, Foot et al. described a chest escharotomy model for use in conjunction with high-fidelity human medical simulators.²²

CONCLUSION

This case series describes the care of two patients who had chest escharotomies by flight physicians in the out-of-hospital setting, with significant improvement in patient ventilation after each procedure. Chest escharotomy is a rare procedure, and chest escharotomy by paramedic-level personnel is confounded by logistic issues of education and scope of practice.

References

- Wallace AB. Assessment and emergency treatment of burns. *Br Med J*. 1955;2:1136–8.
- Bennett JE, Lewis E. Operative decompression of constricting burns. *Surgery*. 1958;43:949–55.
- Wilson BJ, Stirman JA. Initial treatment of burns. *JAMA*. 1960;173:509–16.
- Piccolo NS, Piccolo MS, Piccolo PD, Piccolo-Daher R, Piccolo ND, Piccolo MT. Escharotomies, fasciotomies and carpal tunnel release in burn patients—review of the literature and presentation of an algorithm for surgical decision making. *Handchir Mikrochir Plast Chir*. 2007;39:161–7.
- Ivy ME, Possenti PP, Kepros J, et al. Abdominal compartment syndrome in patients with burns. *J Burn Care Rehabil*. 1999;20:351–3.
- Ivy ME, Atweh NA, Palmer J, Possenti PP, Pineau M, D’Aiuto M. Intra-abdominal hypertension and abdominal compartment syndrome in burn patients. *J Trauma*. 2000;49:387–91.
- Burd A, Noronha FV, Ahmed K, et al. Decompression not escharotomy in acute burns. *Burns*. 2006;32:284–92.
- Tsoutsos D, Rodopoulou S, Keramidias E, Lagios M, Stamatopoulos K, Ioannovich J. Early escharotomy as a measure to reduce intraabdominal hypertension in full-thickness burns of the thoracic and abdominal area. *World J Surg*. 2003;27:1323–8.
- American Burn Association. Annual Report. Available at: <http://www.ameriburn.org/2010NBRAnnualReport.pdf>. Accessed 5 April 2010.

10. U.S. Fire Administration: Quick stats. Available at: <http://www.usfa.dhs.gov/statistics/quickstats/index.shtm>. Accessed on 5 April 2010.
11. Pruitt BA Jr, Dowling JA, Moncrief JA. Escharotomy in early burn care. *Arch Surg*. 1968;96:502-7.
12. O'Mara MS, Caushaj P, Goldfarb IW, Slater H. Treatment and mortality trends among massively burned patients. *Ann Burns Fire Disasters*. 2000;13(2):73.
13. Tekin A, Namias N, O'Keeffe T, et al. A burn mass casualty event due to boiler room explosion on a cruise ship: preparedness and outcomes. *Am Surg*. 2005;71:210-5.
14. Treat RC, Sirinek KR, Levine BA, Pruitt BA Jr. Air evacuation of thermally injured patients: principles of treatment and results. *J Trauma*. 1980;20:275-9.
15. Kirksey TD, Dowling JA, Pruitt BA Jr, Moncrief JA. Safe, expeditious transport of the seriously burned patient. *Arch Surg*. 1968;96:790-4.
16. Harvey JS, Watkins GM, Sherman RT. Emergent burn care. *South Med J*. 1984;77:204-14.
17. Pegg SP. Escharotomy in burns. *Ann Acad Med Singapore*. 1992;21:682-4.
18. Meade RJ. The prevention of secondary tissue destruction in burns. *Plast Reconstr Surg Transplant Bull*. 1958;21:263-71.
19. Burns. In: Sanders MJ, McKenna KD, Quick G, Lewis LM (eds). *Mosby's Paramedic Textbook*. 3rd ed. St. Louis, MO: Elsevier Mosby, 2007, pp 558-79.
20. Baack BR, Smoot EC 3rd, Kucan JO, Riseman L, Noak JF. Helicopter transport of the patient with acute burns. *J Burn Care Rehabil*. 1991;12:229-33.
21. Ali S, Potokar TS, Chamania S, Lohana P, Price P, Whitaker IS. A novel, cost effective escharotomy simulator and trainee assessment. *Burns*. 2008;34:531-2.
22. Foot C, Host D, Campher D, et al. Moulage in high-fidelity simulation—a chest wall burn escharotomy model for visual realism and as an educational tool. *Simul Healthc*. 2008;3:6183-5.