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Hyperbaric oxygen therapy for delayed treatment of frostbite

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Burma, Fudgie the Whale, and Tchaikovsky?

Case report

- 55 year-old male referred on March 30, 2011 from occupational medicine for wound evaluation
- Sustained a frostbite to his right third finger on February 15, 2011
- Treatment by occupational medicine had included dry dressings, finger splint, diclofenac
- Pain persisted despite treatment (rated 8 out of 10)
- Patient is right-hand dominant

Additional history

- Patient worked as a “de-molder” in an ice cream factory
- De-molding process involves:
  1. Donning both waterproof and rubber gloves
  2. Picking up cakes (in mold) flash-frozen to -120 deg F from conveyor belt
  3. Dipping mold in warm water, then hitting mold against hard object to loosen it
- These steps are repeated for each cake that is manufactured

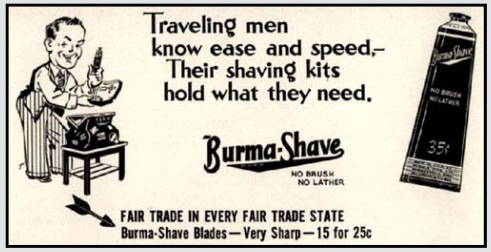
Additional history

- On the day of his injury, the patient likely had an unrecognized hole in his glove(s)
- Repeated contact between the finger, frozen cake mold, and warm water led to frostbite injury
- Despite the injury, the patient was still working in a cold environment
  - "It's an ice cream factory, I can't not be in the cold"

Physical examination

- On examination, a 1.5 x 1.5 cm dry, scabbed area was visible at the distal radial side of the right third finger
- The area was tender to palpation
- Capillary refill was less than three seconds

Right third finger



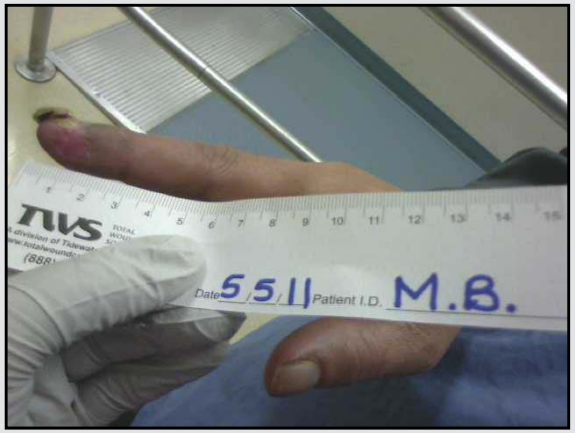
- Due to failure of conservative treatment for more than thirty days, the patient was evaluated for possible treatment with hyperbaric oxygen therapy (HBO_2T)
  - No contraindications to HBO_2T were identified
- Insurance pre-authorization for 20 HBO_2T sessions was requested and obtained
- Translation service was utilized
  - Patient was non-English speaking, spoke Karen only

Hyperbaric treatment

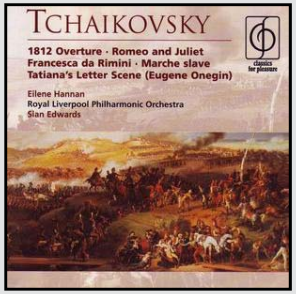
- Pt began HBO_2T on April 6, 2011
  - 2.2 ATA, 90 minutes at 100% O_2
- Even with Karen translator, the patient was unable to equalize pressures in his ears
  - Required bilateral P/E tube placement by ENT
- By the seventh treatment, his pain had decreased to a 5 out of 10
- Remainder of treatments were completed without complications

Hyperbaric treatment

- By the twentieth treatment, pain was decreased to a 3 out of 10
- Patient felt that he could resume his former job duties
- On examination, scabbed area had healed and was not tender



Frostbite



- Tissue freezing, caused by heat loss, sufficient to cause ice crystal formation in the skin
- Severity of injury is related to:
  - Temperature gradient at the skin surface
  - Duration of exposure
- Early descriptions of frostbite pathophysiology date back to Napoleon's invasion of Russia in 1812

Frostbite

- Cellular damage occurs after formation of intra- and extra-cellular ice crystals
- Ice crystal expansion causes destruction of cells
  - Increased osmotic gradients lead to free water transfer into and out of cells
  - Cellular enzyme, pH, and electrolyte changes occur
- Vasoconstriction alternating with vasodilatation causes further damage
  - Repeated freeze/thaw cycles leads to reperfusion injury

Hyperbaric oxygen therapy and frostbite

- Beneficial mechanisms of action of HBO_2T in the treatment of frostbite include:
  - Hyperoxygenation
  - Vasoconstriction
  - Neovascularization
- Medical literature concerning the use of HBO_2T for frostbite demonstrates mixed outcomes
  - Early and delayed treatment

Hyperbaric oxygen therapy and frostbite

- Weaver LK, Greenway L, Elliott CG. Controlled frostbite injury to mice: outcome of hyperbaric oxygen therapy. Journal of hyperbaric medicine 1988;3(1):35-44.
  - Studied the effect of HBO_2T on tissue loss in a murine frostbite model
  - Mice given hypothermic injury to ears
  - Treated with hyperbaric air (sham) or oxygen (2.8 ATA, 90 minutes)

Hyperbaric oxygen therapy and frostbite

- Weaver LK, Greenway L, Elliott CG. Controlled frostbite injury to mice: outcome of hyperbaric oxygen therapy. Journal of hyperbaric medicine 1988;3(1):35-44.
  - No statistically different reduction of tissue loss in HBO_2T group compared to air group
  - Overall, less tissue loss occurred in the HBO_2T group when frostbite was less severe
  - Question of whether HBO_2T is more beneficial in minor frostbite injuries

Hyperbaric oxygen therapy and frostbite

- Von Heimburg D, Noah EM, Sieckmann UP, et al. Hyperbaric oxygen treatment in deep frostbite of both hands in a boy. Burns 2001;27:404-408.
  - 11 year-old boy sustained frostbite to six fingers
  - Surgeon recommended amputation; relative recommended second opinion at a University Hospital
  - Starting on day seven post-injury, was treated with daily HBO_2T (2.4 ATA, 90 minutes at 100% O_2), for fourteen days
  - Complete healing was achieved

Hyperbaric oxygen therapy and frostbite

- Folio LR, Arkin K, Butler WP. Frostbite in a mountain climber treated with hyperbaric oxygen: case report. Military Medicine 2007;172(5):560-563.
  - 28 y/o female developed frostbite to fingers over a two-day period while mountain climbing
  - HBO_2T initiated two weeks after her injury
  - Received twenty-one treatments over three months (treatment protocol unknown)
  - Complete recovery except for “misshapen” appearance of one finger

Conclusions

- HBO_2T may be beneficial in the treatment of acute and delayed frostbite injury
- Less severe frostbite injuries (higher temperatures, slower rate of freezing) may respond better to HBO_2T
- A well-written letter can help to facilitate insurance approval for non-traditional HBO_2T indications

References

- Folio LR, Arkin K, Butler WP. Frostbite in a mountain climber treated with hyperbaric oxygen: case report. Military Medicine 2007;172(5):560-563.
- Imray C, Grieve A, Dhillon S, et al. Cold damage to the extremities: frostbite and non-freezing cold injuries. Postgraduate Medical Journal 2009;85:481-488.
- Murphy J, Banwell PE, Roberts AHN, et al. Frostbite: pathogenesis and treatment. Journal of Trauma, Injury, and Critical Care 2000;48(1):171-178.
- Von Heimburg D, Noah EM, Sieckmann UP, et al. Hyperbaric oxygen treatment in deep frostbite of both hands in a boy. Burns 2001;27:404-408.
- Weaver LK, Greenway L, Elliott CG. Controlled frostbite injury to mice: outcome of hyperbaric oxygen therapy. Journal of hyperbaric medicine 1988;3(1):35-44.