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Topic: Space Medicine

Title: Extraterrestrial hemorrhage control: Terrestrial developments in technique, technology, and philosophy with applicability to traumatic hemorrhage in space

Text: Introduction: Managing injury and illness during long duration space flight limits efforts to explore beyond low earths orbit. Traumatic injury may be expected to occur in space and is a frequent cause of preventable deaths, often related to uncontrolled or ongoing hemorrhage (H). Such bleeding causes 40% of terrestrial injury mortality. Current guidelines emphasize early control of H compared to intravenous infusions. Recent advances in surgical and critical care may be applicable to trauma care in space, with appropriate considerations of the extreme logistical and personnel limitations. Methods: Recent developments in technique, resuscitation fluids, hemoglobin (Hb) substitutes, hemostatic agents, interventional angiography, damage control principles, and concepts related to suspended animation were reviewed. Results: H associated with instability frequently requires definitive intervention. Direct pressure should be applied to all compressible bleeding, but novel approaches are required for intracavitary noncompressible bleeding. Intravenous hemostatic agents such as recombinant Factor VII may facilitate hemostasis especially when combined with a controlled hypotension approach. Both open and laparoscopic techniques could be used in weightlessness, but require technical expertise not likely to be available. Specific rehearsed invasive techniques such as laparotomy with packing, or arterial catheterization with robotic intravascular embolization might be considered. Hemodynamic support, thermal manipulation, or pharmacologic induction of a state of metabolic down regulation for whole body preservation may be appropriate. Hypertonic saline, with or without dextran, may temporize vascular support and decrease reperfusion injury, with less mass than other solutions. Hb substitutes have other theoretical advantages. Conclusions: Terrestrial developments suggest potential novel strategies to control H in space, but will require a coordinated program of evaluation and training to evaluate.

Learning Objectives:

Order	Learning Objectives
1	The risks of traumatic hemorrhage in space as well as the physiologic implications
2	Terrestrial developments in resuscitation that may be applied to austere environments are reviewed
3	Medical developments in hemorrhage control that may be applied to austere but technically controlled environments are reviewed