WHITE PAPER

ECONOMIC BENEFITS OF THE BELMONT® RAPID INFUSER

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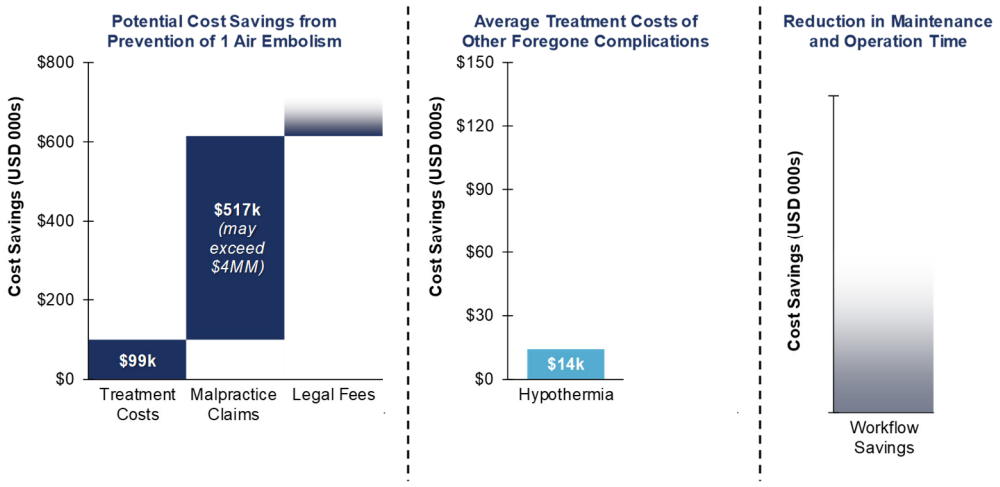
By: Jeff Bessen† Ph.D., Andrew Millar†, Darcy Krzynowek†, Mark Speers†

ABSTRACT

Rapid infusion of fluids provides significant, often lifesaving, clinical benefits for patients experiencing severe blood loss. However, rapid fluid infusion carries risks including venous air embolism (VAE), hypothermia, and water bath-based infuser related bloodstream infection.

The Belmont Rapid Infuser is a medical device with advanced features designed to infuse fluids at a wide range of flow rates while reducing the clinical risk of complications and minimizing the economic burden of massive transfusions. The Belmont is easy to operate and uses electromagnetic induction to provide instantaneous dry heating. Other infusers rely on water bath technology and take significantly longer to warm up. The rapid heating mechanism of The Belmont ensures fast treatment in situations where each minute of delay is associated with a 5% increase in mortality. Safety features include air bubble detection with ultrasonic sensors and automatic air removal from infusion fluids to prevent VAE, and instant and precise heating to prevent cold fluid-induced hypothermia. Prevention of these conditions has the potential to improve patient outcomes while eliminating complications with high per-event average treatment costs, including VAE ($98,900) and hypothermia ($14,100). In addition to the savings from avoided complications, the features of The Belmont also mitigate potential litigation costs, with median closed claims for air embolism patients valued at $517,000 per event, not including legal fees.



The Belmont Rapid Infuser has additional safety and convenience advantages for providers, which may be especially valued in settings that infrequently perform rapid infusions such as lower patient volume rural or community hospitals. The Belmont's dry heating technology requires minimal maintenance, especially compared to water bath-based fluid warmers that require monthly cleaning. Disposables are pre-assembled, color-coded, and do not require calibration for variable flow rates, allowing for rapid setup and deployment, even by infrequent users. A touchscreen display provides on-screen setup instructions, key datapoints during infusion, and operational alarms with instructions for corrective measures.

In summary, The Belmont Rapid Infuser offers optimal clinical performance for patients in addition to economic benefits to providers. The Belmont Rapid Infuser delivers significant clinical and economic value over other systems used in massive transfusions such as the

Smiths Level 1 H-1200 due to faster time to treatment, avoided costs of treating complications of infusions, improved litigation risk management, and reduced staff time requirements for operation and maintenance.

INTRODUCTION

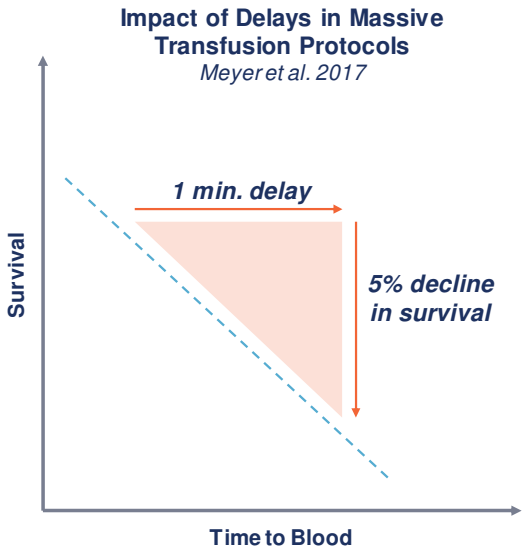
Rapid infusion improves survival and clinical outcomes in severely injured patients[1]. "Rapid infusion" is typically defined as infusion of ten units of blood over a 24-hour period[2] or three units of blood in a one-hour period[3]. The clinical need for rapid infusion can arise during severe trauma, post-partum hemorrhage (PPH), and liver or other organ transplants[2].

Hospitals and trauma societies such as the American College of Surgeons are increasingly developing specific massive transfusion protocols (MTPs) to mitigate the risks to severely bleeding patients[4-6]. These risks include venous air embolism[7], perioperative hypothermia[8],and water bath-based infuser related bloodstream infection. The negative consequences associated with sub-optimal rapid transfusions translate into worse clinical outcomes[7,10] and increased medical costs[11,12]. In rural facilities or settings where trauma patients are encountered less frequently, there are even greater risks when performing massive transfusions, possibly because staff rarely perform the procedures or utilize infusion equipment without advanced safety features[13]. As a result of these and other factors, trauma patients in rural settings experience higher mortality rates than those in urban settings[14,15].

In order to prevent infusion complications, MTP guidelines call for warmed fluids[6,16] and monitoring for air emboli[17]. Among the several devices available to hospitals for facilitating MTPs, only The Belmont Rapid Infuser has a suite of advanced safety and efficiency features that deliver superior clinical performance while offering economic benefits to providers.

LIFESAVING POTENTIAL OF THE BELMONT RAPID INFUSER

The need for massive transfusions may arise at any time in any care setting. The aforementioned clinical situations in which massive transfusions may be required (severe trauma, PPH, and organ transplants) are widespread in the US. According to the National Trauma Data Bank, there were nearly 140,000 incidents of patients with severe or very severe trauma in US hospitals in 2016, resulting in almost 25,000 deaths[18]. The rate of PPH in the United States has been growing[19], and in 2017, an estimated 2.9% of women who give birth in the US experienced excessive bleeding[20]. Additionally, there were over 15,000 liver, heart, and lung transplants in the US in 2019[21].



During massive transfusions, quicker response times translate into saving additional lives and improving patient outcomes[22,23]. One study of MTPs concluded that each minute of delay in delivering blood to patients was associated with a 5% increase in mortality[24]. The Belmont contains advanced time-saving features that ensure transfusions can begin quickly and be carried out optimally every time. The Belmont's dry

electromagnetic induction-based heating technology requires just seconds to warm fluids, e.g. near-frozen blood stored at 4°C, to the proper normothermic temperature (37.5°C)[25], even at very high flow rates. In contrast, water bath-based infusers take significantly longer to warm up. For comparison, a water bath-based rapid infuser, the Level 1 H-1000, required up to 8 minutes to achieve the proper temperature[26]. Even infusers that utilize other dry heating mechanisms, such as conductive plate warming, can take minutes to heat up[26]. The Belmont is the only rapid infuser with an intuitive touchscreen interface that provides visual and descriptive alarms if set-up errors are detected. When errors are detected, the touchscreen provides instructions to implement corrective measures. Finally, The Belmont disposables are color-coded and preassembled (with the reservoir, patient line, and heat exchanger already connected for easy installation), further accelerating patient time to treatment.

"Every effort should be made to decrease the time to recognition of the need for MTP and the time to administration of the first blood product." – Meyer et al. 2017

PREVENTION OF AIR EMBOLI WITH THE BELMONT RAPID INFUSER

Venous air embolism (VAE) is caused by introduction of air bubbles into the bloodstream, often resulting in organ or neurological damage, or death[27]. Air can be introduced via rapid transfusion during insertion or removal of the catheter, through failure to remove air from blood or fluid bags[7], through outgassing of warmed fluids[28], or if line disconnection occurs[29]. The incidence of symptomatic VAE may be as high as 2%[28], and estimates of mortality rates range from 23-50%[29,30]. Non-fatal complications of VAE include hemodynamic instability, neurologic damage, and end-organ damage[31]. Treatment of these complications typically requires longer hospitalizations, ranging from 3 additional days in the ICU to 9 added days in the hospital overall[32,33].

The Belmont Rapid Infuser eliminates the risk of air emboli by detecting and automatically removing air bubbles without affecting fluid resuscitation. In a head-to-head comparison, the air removal performance of The Belmont Rapid Infuser was shown to be superior to that of other rapid infusers such as the Level 1 Rapid Infuser[25]. In one such study, the Belmont Rapid Infuser successfully removed a life-threatening bolus of air (10 mL), while much of the air remained in the tubing of the Level 1[25].

The prevention of air emboli using The Belmont Rapid Infuser results in significant economic benefits. One study calculated that in 2008, average costs associated with inpatient air emboli totaled an average of $72,222 per patient[11] ($98,900 in 2019 dollars). Major components of this added cost include diagnostic imaging, supportive therapy, and extended hospitalization.

$98,900
AVG. TREATMENT COST SAVINGS FROM PREVENTING ONE AIR EMBOLISM

$4MM+
MAXIMUM PAYOUT FOR CLOSED LITIGATION CLAIMS REGARDING AIR EMBOLISM

Significantly, in 2007, CMS announced that it would no longer reimburse the cost of treating complications of preventable medical errors including VAE[34], a policy which other payers have subsequently advocated[35]. Finally, VAE may result in costly litigation, with reports of median closed claims ranging from $325,000 to $517,000 and maximum payouts exceeding $4MM[36,37].

In summary, prevention of a single air embolism event with The Belmont could save a patient's life and provide substantial economic value to the hospital.

REDUCING HYPOTHERMIA WITH THE BELMONT RAPID INFUSER

Hypothermia is typically defined as a core body temperature less than 36°C, which may impair the clotting ability of blood and result in worse patient outcomes[38]. Massive transfusions can lead to inadvertent hypothermia if fluids are not properly warmed prior to infusion[8]. For example, infusion of one unit of refrigerated blood, or one liter of room-temperature fluid, has the potential to decrease core body temperature by 0.25°C[39,40]. Hypothermia occurs frequently in severe trauma patients, with rates as high as 50%[41]. Indeed, hypothermia as well as acidosis and coagulopathy comprise the "lethal triad" of abnormalities which can exacerbate each other in cases of traumatic hemorrhage, and which may result in death[5]. Studies have shown that patients displaying hypothermia require increased volumes of blood transfusions[42,43], which is a negative predictor of outcomes including infection and mortality[5,44]. Additionally, the infusion of cold fluid itself can lead to increased risk of cardiac events[45] or infection[46] and extended hospitalization[47].

The Belmont Rapid Infuser minimizes the risk of inadvertent hypothermia by instantly and precisely heating fluids using dry electromagnetic induction technology. The fluid warming capability of induction-based warmers such as The Belmont Rapid Infuser have been shown to be superior to that of other infusers[25,26,48]. For example, at a flow rate of 500 mL of packed red blood cells (PRBCs) per minute, The Belmont Rapid Infuser maintained a physiological temperature; in contrast, the Level 1 infusate temperature declined over time by 3°C[25]. The Belmont temperature probe directly measures the temperature of the infusate, while other systems such as the Level I measure the temperature of the bath that is used to heat the infusate. Even infusers that use other dry heating mechanisms, such as conductive plate warming, have been found to warm the infusate to sub-normothermic temperatures[49,50].

$14,100
AVG. TREATMENT COST SAVINGS FROM ONE NORMOTHERMIC TRANSFUSION

Mitigation of perioperative hypothermia using The Belmont Rapid Infuser may yield significant economic value and savings. On average, patients presenting with hypothermia require an increase of 1.3 units of PRBCs transfused[42]. Researchers have found total transfusion costs can reach $1,180 per PRBC unit[51] ($1,675 in 2019), potentially resulting in extra costs for hypothermic patients of $2,000 or more from increased blood-usage alone. In total, complications stemming from hypothermia of 1.5°C below normal were found to cost an average of $7,074 per patient[52] ($14,100 in 2019). For those patients that suffer cardiac complications of hypothermia--including unstable angina, cardiac arrest, or myocardial infarction – costs may be even higher, with estimates ranging up to $25,000[53] ($29,300 in 2019). Finally, hypothermic patients require increased hospitalization averaging 3 additional days[47], at costs ranging from $1,850 to $3,780 per patient per day[54] ($2,000 and $4,000 in 2019).

Taken together, the cost savings from normothermic transfusion with The Belmont Rapid Infuser may range from decreased blood usage ($2,000+) to decreased complications and hospitalization (tens of thousands of dollars).

MINIMIZING THE RISK OF WATER BORNE RELATED BLOODSTREAM INFECTION WITH DRY HEATING

Hospital-acquired bloodstream infections, which are typically considered to be preventable[55], have been linked to the use of water bath-based fluid warmers[56]. Rapid infusers that use water

baths for warming, such as the Level 1 Rapid Infuser, may therefore pose additional risks of infection, as the warm water can serve as a reservoir for pathogens[9,57,58] which can come into contact with the infusate. The risks associated with water baths have been highlighted in AABB guidelines for blood warming devices[59]. Indeed, there have been reports of infusers with water baths failing, resulting in water bath fluid being infused into the patient[60-62]. In at least one instance, physicians concluded that a surgical patient contracted a bloodstream infection due to mechanical failure of a Level 1 Rapid Infuser[9], with the patient requiring 51 days of hospitalization. Indeed, patients that develop hospital-acquired infections require additional treatment and commonly experience extended hospitalization[63]. Trauma patients in particular are at an elevated risk of mortality, longer hospitalization, and increased costs resulting from hospital-acquired infections[64].

$113,300
AVG. TREATMENT COST SAVINGS FROM PREVENTING A BLOODSTREAM INFECTION

Water baths have been linked to potential fluid contamination and bloodstream infections. The dry heating source of The Belmont Rapid Infuser eliminates the need for a water bath heat source, mitigating the risk of fluid contamination from the water bath. Hospital-acquired bloodstream infections are thought to result in 150 excess deaths for every 1,000 cases[12]. Estimates place attributable costs of hospital-acquired bloodstream infections to be $82,730 ($113,300 in 2019) on average, depending on the hospital setting[63,65]. In addition, Medicare has instituted a hospital-acquired condition reduction program, which may result in reduced reimbursement overall for hospitals that fail to reduce hospital-acquired infections[66]. The Belmont Rapid Infuser utilizes dry, instant electromagnetic heating and does not use a water bath.

ADDITIONAL BENEFITS OF THE BELMONT RAPID INFUSER

The Belmont includes numerous additional safety and convenience features to optimize infusion at a wide range of flow rates for healthcare providers. These features – including color-coded disposables, a descriptive touchscreen interface, automatic air removal, battery operation, and a low-maintenance heating source – may appeal particularly to settings that infrequently perform rapid infusions[13]. The Belmont uses the same disposable set regardless of the desired flow rate[67], simplifying operations. The Belmont has numerous integrated alarms with visual on-screen cues including over- and under-temperature, problems with disposables, and high pressure[67], potentially saving time in emergency scenarios. The automatic air detection and removal system enables a single operator to oversee the transfusion, reducing the burden on hospital staff. In addition, the reduced staffing required to operate The Belmont may result in fewer distractions in the ED or OR. Indeed, multiple studies have shown interruptions and distractions in healthcare settings to be associated with increased rates of medical errors and complications such as patient hemorrhage[68,69]. Finally, The Belmont's dry heat source requires minimal maintenance, a convenience feature that is noted in AABB guidelines[59]. In contrast, rapid infusers that employ water baths require maintenance every 30 days[70], a guideline which some hospitals may not follow[9]. There are also reports of water bath-based warming devices leaking or causing electrical shocks to healthcare providers[62].

In summary, the ease-of-use features of The Belmont may lead to faster infusion of blood, improved workflow, and time savings for hospital staff, even for inexperienced users.

DISCUSSION

The Belmont offers numerous clinical and economic benefits for all hospitals. Foremost, it saves lives by ensuring rapid and safe delivery of fluids to patients in the most critical of situations. It offers improved clinical performance for patients by preventing complications associated with infusion, such as VAE, inadvertent hypothermia, and water bath-based infuser related bloodstream infection . By reducing complications and the associated treatments, excess hospitalization, and potential litigation, use of The Belmont could result in substantial economic benefits for providers. Altogether, The Belmont's advanced features can assist hospitals in optimizing their MTP, resulting in improved efficiency and response times, better clinical performance, and superior health economic benefits relative to other infusion devices.

METHODOLOGY

A targeted literature search was conducted to better understand the clinical benefits and cost-savings associated with use of rapid infusion devices, including The Belmont Rapid Infuser, for intravenous fluid delivery. Key words included: rapid infusion, infusion device, transfusion, massive transfusion protocol, resuscitation, air embolism, air elimination, infusion-related air embolism, microbubble, blood-liquid warmer, fluid warming, fluid warmer, prehospital hypothermia, perioperative hypothermia, dry heat source, water bath, water reservoir, hospital-acquired infection, catheter infection, postpartum hemorrhage, trauma, pressure bags, Belmont, Belmont Rapid Infuser, Belmont Rapid Infuser RI-2, FMS2000, Smiths Level 1, Hotline, Fluido, Ranger, Thermacor, Warmflo, and Gaymar. Searches also included closely related phrases and alternate spellings. The above key words were combined with economic terms such as costs, budget impact, price, and cost-effectiveness, to identify literature with relevant economic components.

For ease of comparison, cost estimates were adjusted to 2019 levels based on the US Bureau of Labor Statistics medical care price index. Between 2000 and 2019, inflation for medical care increased by an average of 3.5% annually, with a high of 4.7% and a low of 2.0%.

REFERENCES

1. Cotton BA, Au BK, Nunez TC, Gunter OL, Robertson AM, Young PP. Predefined massive transfusion protocols are associated with a reduction in organ failure and postinjury complications. J Trauma 2009;66:41-8; discussion 8-9.
2. Hess JR. Massive blood transfusion. UpToDate 2019.
3. Savage SA, Sumislawski JJ, Zarzaur BL, Dutton WP, Croce MA, Fabian TC. The new metric to define large-volume hemorrhage: results of a prospective study of the critical administration threshold. J Trauma Acute Care Surg 2015;78:224-9; discussion 9-30.
4. Riskin D, TC Tsai, L Riskin, T Hernandez-Boussard, M Purtill, PM Maggio, DA Spain, and SI Brundage. Massive transfusion protocols: the role of aggressive resuscitation versus product ratio in mortality reduction. J Am Coll Surg 2009;209:198-205.
5. Sihler KC, Napolitano LM. Complications of massive transfusion. Chest 2010;137:209-20.
6. --. Trauma Quality Improvement Program: Massive Transfusion in Trauma Guidelines. American College of Surgeons 2014.
7. Cook LS. Infusion-related air embolism. J Infus Nurs 2013;36:26-36.
8. Zafren K, Mechem C. Accidental hypothermia in adults. UpToDate 2019.
9. McLellan E, Clark B, Townsend R. Mechanical failure of a Level 1 Rapid Infuser as a potential source of septicaemia. J Hosp Infect. England2007:399-401.
10. Bukur M, Hadjibashi AA, Ley EJ, et al. Impact of prehospital hypothermia on transfusion requirements and outcomes. J Trauma Acute Care Surg 2012;73:1195-201.
11. Van Den Bos J, Rustagi K, Gray T, Halford M, Ziemkiewicz E, Shreve J. The $17.1 billion problem: the annual cost of measurable medical errors. Health Aff (Millwood) 2011;30:596-603.
12. --. Estimating the Additional Hospital Inpatient Cost and Mortality Associated With Selected Hospital-Acquired Conditions. AHRQ 2017;https://www.ahrq.gov/hai/pfp/haccost2017.html.
13. Parker MJ, Manan A. Translating Resuscitation Guidelines into Practice: Health Care Provider Attitudes, Preferences and Beliefs Regarding Pediatric Fluid Resuscitation Performance. PLoS One2013.
14. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: geographic disparities in trauma mortality. Surgery 2016;160:1551-9.
15. Fleet R, Lauzier F, Tounkara FK, et al. Profile of trauma mortality and trauma care resources at rural emergency departments and urban trauma centres in Quebec: a population-based, retrospective cohort study. BMJ Open 2019;9:e028512.
16. Riley C AJ. Inadvertent perioperative hypothermia. BJA Education 2018;18:227-33.
17. --. FDA Safety Communication: Intravascular Air-in-Line and Air Embolism Risks Associated with Infusion Pumps, Fluid Warmers, and Rapid Infusers. FDA 2019.
18. --. National Trauma Data Bank Annual Report 2016. National Trauma Data Bank 2016;https://www.facs.org/-/media/files/quality-programs/trauma/ntdb/ntdb-annual-report-2016.ashx.
19. Kramer MS, Berg C, Abenhaim H, et al. Incidence, risk factors, and temporal trends in severe postpartum hemorrhage. Am J Obstet Gynecol 2013;209:449.e1-7.
20. --. Maternal Morbidity and Mortaliy. AWHONN Postpartum Hemorrhage Project 2017;http://www.pphproject.org/maternal-morbidity-mortality.asp.
21. --. Transplant trends. United Network for Organ Sharing 2019;https://unos.org/data/transplant-trends/.
22. Chatrath V, Khetarpal R, Ahuja J. Fluid management in patients with trauma: Restrictive versus liberal approach. J Anaesthesiol Clin Pharmacol 2015;31:308-16.

23. Mitra B, Bade-Boon J, Fitzgerald MC, Beck B, Cameron PA. Timely completion of multiple life-saving interventions for traumatic haemorrhagic shock: a retrospective cohort study. Burns & Trauma 2019;7:22.
24. Meyer DE, Vincent LA, Fox EE, et al. Every minute counts: Time to delivery of initial massive transfusion cooler and its impact on mortality. J Trauma Acute Care Surg 2017;83:19-24.
25. Comunale ME. A laboratory evaluation of the level 1 rapid infuser (H1025) and the Belmont instrument fluid management system (FMS 2000) for rapid transfusion. Anesth Analg 2003;97:1064-9, table of contents.
26. Dubick MA, Brooks DE, Macaitis JM, Bice TG, Moreau AR, Holcomb JB. Evaluation of commercially available fluid-warming devices for use in forward surgical and combat areas. Mil Med 2005;170:76-82.
27. McCarthy CJ, Behravesh S, Naidu SG, Oklu R. Air embolism: Diagnosis, clinical management and outcomes. Diagnostics (Basel) 2017;7.
28. Erkin Y, Tasdogen A, Gonullu E. Is there risk of emboli during infusion with line type blood-liquid warmers? Braz J Anesthesiol 2013;63:389-92.
29. Heckmann JG, Lang CJ, Kindler K, Huk W, Erbguth FJ, Neundorfer B. Neurologic manifestations of cerebral air embolism as a complication of central venous catheterization. Crit Care Med 2000;28:1621-5.
30. Kashuk JL, Penn I. Air embolism after central venous catheterization. Surg Gynecol Obstet 1984;159:249-52.
31. O'Dowd L, Kelley M. Air embolism. UpToDate 2019.
32. Saladino A, Lamperti M, Mangraviti A, et al. The semisitting position: analysis of the risks and surgical outcomes in a contemporary series of 425 adult patients undergoing cranial surgery. J Neurosurg 2017;127:867-76.
33. Bessereau J, Genotelle N, Chabbaut C, et al. Long-term outcome of iatrogenic gas embolism. Intensive Care Med 2010;36:1180-7.
34. --. Medicare Program; Changes to the Hospital Inpatient Prospective Payment Systems and Fiscal Year 2008 Rates. Federal Register 2007;72 FR 47129.
35. --. Never events. The Leapfrog Group 2016;https://www.leapfroggroup.org/sites/default/files/Files/Castlight-Leapfrog_Never_Events_Final.pdf.
36. Domino KB, Bowdle TA, Posner KL, Spitellie PH, Lee LA, Cheney FW. Injuries and liability related to central vascular catheters: a closed claims analysis. Anesthesiology 2004;100:1411-8.
37. Brull SJ, Prielipp RC. Vascular air embolism: A silent hazard to patient safety. J Crit Care 2017;42:255-63.
38. Gentilello LM, Pierson DJ. Trauma critical care. Am J Respir Crit Care Med 2001;163:604-7.
39. Putzu M, Casati A, Berti M, Pagliarini G, Fanelli G. Clinical complications, monitoring and management of perioperative mild hypothermia: anesthesiological features. Acta Biomed 2007;78:163-9.
40. Sessler DI. Temperature Monitoring. in Miller's Anaesthaisia, RD Miller, Ed 2005;6th edition:1571-97.
41. Soreide K. Clinical and translational aspects of hypothermia in major trauma patients: from pathophysiology to prevention, prognosis and potential preservation. Injury 2014;45:647-54.
42. Klauke N, Graff I, Fleischer A, et al. Effects of prehospital hypothermia on transfusion requirements and outcomes: a retrospective observatory trial. BMJ Open 2016;6:e009913.

43. Sun Z, Honar H, Sessler DI, et al. Intraoperative core temperature patterns, transfusion requirement, and hospital duration in patients warmed with forced air. Anesthesiology 2015;122:276-85.
44. Dzik WS, Ziman A, Cohn C, et al. Survival after ultramassive transfusion: a review of 1360 cases. Transfusion 2016;56:558-63.
45. Frank SM, Fleisher LA, Breslow MJ, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. Jama 1997;277:1127-34.
46. McSwain J, Yared M, Doty J, Wilson S. Perioperative hypothermia: Causes, consequences and treatment. World J Anestesiol 2015;4:58-65.
47. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. N Engl J Med 1996;334:1209-15.
48. Satoh J, Yamakage M, Wasaki SI, Namiki A. Performance of three systems for warming intravenous fluids at different flow rates. Anaesth Intensive Care 2006;34:46-50.
49. Eaton MP, Dhillon AK. Relative performance of the level 1 and ranger pressure infusion devices. Anesth Analg 2003;97:1074-7, table of contents.
50. Zoremba N, Gruenewald C, Zoremba M, Rossaint R, Schaelte G. Air elimination capability in rapid infusion systems. Anaesthesia 2011;66:1031-4.
51. Shander A, Hofmann A, Ozawa S, Theusinger OM, Gombotz H, Spahn DR. Activity-based costs of blood transfusions in surgical patients at four hospitals. Transfusion 2010;50:753-65.
52. Mahoney CB, Odom J. Maintaining intraoperative normothermia: a meta-analysis of outcomes with costs. Aana j 1999;67:155-63.
53. Nicholson G, Gandra SR, Halbert RJ, Richhariya A, Nordyke RJ. Patient-level costs of major cardiovascular conditions: a review of the international literature. Clinicoecon Outcomes Res2016:495-506.
54. --. HCUP Fast Stats - National Trends in Inpatient Stays. AHRQ 2016;www.hcup-us.ahrq.gov/faststats/national/.
55. Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. Infect Control Hosp Epidemiol 2011;32:101-14.
56. Burns S. An investigation of surgical infections reveals a fluid warmer as a reservoir for bacteria. Am J Infect Control 1999;27:216.
57. Bloomfield S, Exner M, Flemming HC, et al. Lesser-known or hidden reservoirs of infection and implications for adequate prevention strategies: Where to look and what to look for. GMS Hyg Infect Control 2015;10:Doc04.
58. Rutala WA, Weber DJ. Water as a reservoir of nosocomial pathogens. Infect Control Hosp Epidemiol 1997;18:609-16.
59. Hrovat T, Passwater M, Palmer R. Guidelines for the use of blood warming devices. American Association of Blood Banks 2002.
60. DAngelo E. Fluid warmer leakage into the bloodstream: A case report. J Am Assoc Nurse Anesthetists 1995.
61. Wilson S, Szerb J. Failure of an iv fluid warming device. Can J Anaesth. United States2007:324-5.
62. --. MAUDE - Manufacturer and User Facility Device Experience Database. FDA Accessed February 2020;https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/search.CFM.
63. Hollenbeak CS. The cost of catheter-related bloodstream infections: implications for the value of prevention. J Infus Nurs 2011;34:309-13.

64. Glance LG, Stone PW, Mukamel DB, Dick AW. Increases in mortality, length of stay, and cost associated with hospital-acquired infections in trauma patients. Arch Surg 2011;146:794-801.
65. Cohen ER, Feinglass J, Barsuk JH, et al. Cost savings from reduced catheter-related bloodstream infection after simulation-based education for residents in a medical intensive care unit. Simul Healthc 2010;5:98-102.
66. --. Hospital-Acquired Condition Reduction Program (HACRP). CMS 2019;https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/HAC-Reduction-Program.
67. --. Blood/Solution Warming Units. Device Overviews and Specifications 2019;ECRI Institute.
68. Healey AN, Sevdalis N, Vincent CA. Measuring intra-operative interference from distraction and interruption observed in the operating theatre. Ergonomics 2006;49:589-604.
69. Mentis HM, Chellali A, Manser K, Cao CG, Schwaitzberg SD. A Systematic Review of the Effect of Distraction on Surgeon Performance: Directions for Operating Room Policy and Surgical Training. Surg Endosc 2016;30:1713-24.
70. --. Hotline Blood and Fluid Warmer Operator's Manual. Smiths Medical 2013;http://level1hotline.com/pdf/HL-90_4534005-GB%20Rev-010_Print.pdf.

Authors Information

† Employees of Health Advances, LLC, Newton, Massachusetts.

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