ABSTRACTS

Abstracts for the 2012 NAEMSP Scientific Assembly

These are the abstracts for the National Association of EMS Physicians Scientific Assembly, Tucson, Arizona, January 12–14, 2012. **Key words:** EMS; out-of-hospital; emergency medical services; abstracts; National Association of EMS Physicians

1. Comparison of Survival to Hospital Discharge between Integrated AutoPulse CPR and Manual CPR during Out-of-Hospital Cardiac Arrest: The Circulation Improving Resuscitation Care (CIRC) Trial

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Introduction. Quality of chest compressions affects survival from cardiac arrest, and mechanical devices may facilitate maintaining high quality. **Objective.** To compare integrated AutoPulse cardiopulmonary resuscitation (iA-CPR) with high-quality manual CPR (M-CPR) to determine equivalence or superiority of either treatment. **Methods.** A randomized controlled trial of emergency medical services (EMS)-treated adult out-of-hospital cardiac arrests of presumed cardiac origin was conducted at three U.S. and two European study sites between March 2009 and January 2011. Systematic studywide training and monitoring of CPR quality was implemented. Manual compressions were initiated when CPR was indicated. Patients were then randomized to receive iA-CPR or M-CPR. The primary outcome was survival to hospital discharge. Secondary outcomes were return of spontaneous circulation (ROSC), 24-hour survival, and modified Rankin score (MRS) at hospital discharge. The group sequential double triangular test was used to analyze covariate-adjusted survival data at predefined intervals to identify superiority—a log odds ratio (log-OR) of 0.37 (OR 1.44) with a two-sided significance level of 5% and a power of 97.5%—or equivalence, defined as the 95% confidence interval (CI) for the log-OR fully lying between –0.37 and 0.37. **Results.** Of 4,559 eligible patients, 328 (7%) were not enrolled. 2,099 subjects received iA-CPR (49.6%) and 2,132 M-CPR (50.4%). Discharge status was unknown for 12 cases. After adjustment for enrollment site, age, witnessed arrest, and initial cardiac rhythm, survival was statistically equivalent for iA-CPR compared with M-CPR (adjusted OR 1.061, 95% CI 0.829, 1.365). The 95% CI for the log-OR (–0.188 to 0.311) was fully within the equivalence region. There was no significant difference in discharge MRS ≤3 (adjusted OR 0.843, 95% CI 0.618, 1.149). Unadjusted values for iA-CPR and M-CPR were: survival to hospital discharge 9.4% vs. 11.0%, ROSC 28.6% vs. 32.3%, 24-hour survival 21.8% vs. 25.1%, median MRS 2 vs. 2, and hands-off fraction 19.6% vs. 20.2%, respectively. **Conclusions.** Compared with high-quality M-CPR, iA-CPR resulted in statistically equivalent survival to hospital discharge and no difference in neurologic status at discharge in adults with out-of-hospital cardiac arrest of presumed cardiac etiology.

2. Infusing Chilled Saline via the Intraosseous Route Is Equivalent to Infusion via the Intravenous Route in Reducing the Core Temperature in Swine

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Introduction. Therapeutic hypothermia (TH) lowers a patient's body temperature to reduce the extent of ischemic injury to brain tissue following cardiac arrest or stroke. Intraosseous (IO) vascular access may be employed to infuse chilled saline as quickly as possible to achieve TH as an alternative to peripheral intravenous (IV) access. **Objective.** A randomized crossover swine study was designed to compare the reductions in brain temperature during chilled saline infusion via the IV and IO routes and determine whether the two routes are equivalent. **Methods.** Eight adult Yorkshire swine underwent chilled saline infusion, one cycle via IO catheter placed in the proximal humerus and one cycle via IV catheter, allowing each animal to serve as its own control. Infusion route sequencing was randomized. Normal saline, dosed at 30 mL/kg body weight, was infused via infusion pump over 45 minutes. Saline was chilled by submerging the fluid bags and infusion tubing in an ice-water slurry. Animals were rewarmed between cycles to baseline temperature. Brain, esophageal, rectal, and saline infusion temperatures (at the hub of the infusion catheters) were digitally recorded with probes connected to a data recorder (Physitemp Thermes USB, Clifton, NJ), and downloaded to a computer. Statistical equivalence was assessed using the Schuirmann's two one-sided tests procedure. **Results.** The mean weight for the swine was 72.7 kg. The mean starting temperatures for IV infusion were 36.1°C ± 0.9°C brain, 35.7°C ± 1.0°C esophageal, and 36.4°C ± 1.2°C rectal. The mean starting temperatures for IO infusion were 36.0°C ± 1.0°C brain, 35.9°C ± 1.0°C esophageal, and 36.4°C ± 1.2°C rectal. The mean infusion temperature was 7.2°C ± 1.6°C IV and 7.5°C ± 1.8°C IO. The mean temperature reductions for IV infusions were 2.0°C ± 0.3°C brain, 1.6°C ± 0.4°C esophageal, and 1.8°C ± 0.3°C rectal. The mean temperature reductions for IO infusions were 1.7°C ± 0.4°C brain, 1.6°C ± 0.4°C esophageal, and 1.5°C ± 0.3°C rectal. IO and IV brain temperature reductions were statistically equivalent. **Conclusions.** Study results suggest no clinical or statistical difference between IV and IO when comparing the two routes for infusion of chilled saline for TH. This benefits emergency medical services personnel, as IO access is consistently and rapidly achievable for infusions of chilled saline for TH induction, and particularly beneficial to clinicians and patients when IV access cannot be easily obtained.

3. Improvement of Long-Term Neurologic Function after Sudden Cardiac Death and Resuscitation: Impact of CPR Method and Postresuscitation Care

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Introduction. The randomized, prospective, multicenter ResQTrial showed that the combination of active compression–decompression (ACD) cardiopulmonary resuscitation (CPR) plus an impedance threshold device (ITD) (ACD+ITD) resulted in a 53% improved survival to hospital discharge (HD) with favorable neurologic function as compared with standard CPR (S-CPR). **Objective.** Since the restoration and recovery of brain function may continue beyond HD, we hypothesized that patients with poor neurologic function at HD would have a greater likelihood of significant long-term neurologic improvement if they had been resuscitated using ACD+ITD. Further, the use of postresuscitation therapeutic hypothermia (TH) should further optimize outcomes. **Methods.** A post hoc analysis of ResQTrial data compared survival with favorable neurologic function at 90 days, defined as a cerebral performance category (CPC) score ≤ 2, in patients who had poor neurologic function (CPC ≥ 3) at HD. Data were stratified by CPR method and use of TH. Differences in the percentage of patients who improved from CPC ≥ 3 at HD to CPC ≤ 2 at 90 days were analyzed using Fisher's exact test, with a p-value < 0.05 considered to be evidence of statistical significance. **Results.** There were 73 patients in the S-CPR group and 100 patients in the ACD+ITD group who survived to HD and had known CPC and TH status. At 90 days, there were 50 survivors in the S-CPR group and 77 in the ACD+ITD group with known CPC and TH status. There was an overall twofold increase in the percentage of patients who improved from CPC = 3 at HD to CPC = 2 at 90 days in the ACD+ITD group (48.0%, 12/25) compared with the S-CPR group (21.0%, 4/19), but the difference was not statistically significant (p = 0.113). Among patients receiving TH, however, there was a sixfold increase associated with ACD+ITD with TH (69.2%, 9/13) vs. S-CPR with TH (11.1%,

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29 (20%) were normal weight. The mean BMI for the study population was 30 22 kg/m^2. The mean BMI was 22 kg/m^2 for those who were normal weight, 27 kg/m^2 for those who were overweight, and 37 kg/m^2 for those who were obese. There was no statistically significant difference noted when comparing BMI results among emergency medical technician (EMT)-Basics, EMT-Intermediates, and EMT-Paramedics ($p = 0.303$). There was no statistically significant difference in BMI when assessing the number of different EMS organizations at which a participant performed EMS work ($p = 0.689$) or their smoking status ($p = 0.458$). A greater proportion of male participants were overweight or obese when compared with female participants (overweight: 49% vs. 34%; obese: 40% vs. 32%; $p = 0.003$). There were 68 (52%) individuals who met Centers for Disease Control and Prevention (CDC) physical activity recommendations. Those with lower BMI were more likely to meet physical activity recommendations (normal weight 64%; overweight 63%; obese, 27%; $p = 0.013$). **Conclusion.** A large majority of participants in this study were obese or overweight. The only modifiable variable assessed in this study that was significantly associated with higher BMI was physical activity. To ensure a fit workforce, leaders in EMS should investigate strategies to increase physical activity and decrease the BMI of EMS professionals.

89. Prehospital Semiautomatic Intraosseous Placement in Adults

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Introduction. Vascular access traditionally involves peripheral intravenous (IV) catheter placement. An alternative to this practice is placement of a catheter into the intraosseous (IO) space using a semiautomatic drill device. Although IO placement has been traditionally reserved for pediatric patients (primarily because of difficulty in peripheral IV access placement), the advent of more sophisticated IO placement devices has increased its use in the adult population. **Objective.** To determine success rates and features of prehospital IO placement in the adult population with use of a semiautomatic placement device. **Methods.** This descriptive retrospective study examined prehospital records from a multisite ambulance service located throughout Minnesota and western Wisconsin. Data were collected from records using EMSPro software. Implementation of the EZ-IO (Vidacare Corp., Shavano Park, TX) occurred in March 2007. Record review encompassed dates spanning March 2007 through March 2009. This study was approved by the institutional review board. **Results.** There were 281 patients receiving at least one IO attempt. First-attempt success was achieved in 252 (89.7%) cases. Second attempts were made on eight patients, six of which were successful (75.0%). Accounting for all attempts, overall success was achieved for 91.8% (258/281) of patients. Paramedics documented responsiveness on the AVPU (alert, verbal, painful, unresponsive) scale. Responsiveness of the IO recipients was: alert = 8.5% (24), verbal = 5.6% (16), painful = 7.8% (22), and unresponsive = 77.9% (219). In this sample, 172 (61.2%) patients were in cardiac arrest or intubated, and the remaining 109 (38.8%) were not. All "alert" patients received at least one IV attempt prior to IO attempt, vs. 53.4% of unresponsive patients. This is an absolute difference of 46.6% ($p < 0.0001$). Patients experiencing cardiac or respiratory arrest had IV attempts in 47.1% (81/172) of cases, vs. 78.2% (86/110) for nonarrested patients. This is an absolute difference of 30.8% ($p < 0.0001$). **Conclusion.** First-attempt success and overall success are high with the semiautomatic IO device. Over the study period, the device was used in several clinical impressions, primarily cardiac arrest. Providers were more apt to attempt IV access prior to an IO attempt when the patient was not in cardiac or respiratory arrest.

90. Treatment of Hypotensive Patients by EMS Personnel by Modulating Intrathoracic Pressures

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Introduction. An impedance threshold device (ITD) increases the resistance to inspiration, thereby decreasing the intrathoracic pressure to subatmospheric levels. Recent studies have demonstrated that this increases the cardiac stroke volume and systemic blood pressure in spontaneously breathing human subjects and patients. The potential clinical value of harnessing this physiologic response in the treatment of hypotensive patients due to blood loss is unknown. **Objective.** To investigate the effects of ITD application on hypotensive patients due to blood loss. **Methods.** The ITD was evaluated in four emergency medical services (EMS) systems in the United States, and it was applied to hypotensive patients if the emergency responders determined that the indications for its use were met. There were 259 patients treated, and of those, 25 patients had blood loss and hypotension. Vital signs were measured before, during, and after ITD application, with the primary endpoints being systolic blood pressure (SBP) and diastolic blood pressure (DBP). Patient tolerance was also evaluated. For analysis of the results, paired Student's t-tests were used. **Results.** For the 25 patients with hypotension due to blood loss, the mean ± standard deviation of the SBP and DBP before ITD application (82 ± 14 mmHg and 46 ± 14 mmHg, respectively) increased ($p = 0.01$) to 99 ± 23 mmHg and 55 ± 16 mmHg after ITD application. For all 259 patients, SBP and DBP before ITD application (79 ± 13 mmHg and 46 ± 13 mmHg) increased ($p = 0.01$) to 106 ± 19 mmHg and 63 ± 13 mmHg after ITD application. Patients treated with intravenous (IV) fluids and ITD ($n = 204$) versus ITD alone and without IV fluids ($n = 55$) had similar hemodynamics during ITD use. Less than 10% of patients reported having significant difficulty breathing through the ITD. **Conclusions.** Breathing through an ITD was well tolerated in hypotensive patients during prehospital transport. Regardless of the cause, application of the ITD significantly raised blood pressures in hypotensive patients. These results support the potential use of the ITD to avoid circulatory shock in hemorrhaging patients until more definitive care becomes available.

91. Comparison of Devices for Emergency Treatment of Open Pneumothorax

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Introduction. Prehospital treatment for open pneumothorax consists of wound occlusion with a chest seal. It should also allow some means of externally venting intrathoracic pressure. Factors contributing to ineffective treatment include occlusion of the venting mechanism by fluids, external obstruction, or separation of the seal from the skin. Arnaud et al. (2008) evaluated two devices, the Asherman Chest Seal (ACS) and the Bolin Chest Seal (BCS), against occlusion by blood, fluids, and separation in swine. **Objectives.** The current study evaluated 1) venting function (internal and external) for the SAM Chest Seal (SCS), the ACS, and the BCS; and skin adhesion for those dressings and the unvented HALO Chest Seal (HCS). **Methods.** Venting function: Nine Yorkshire swine were prepared using the Arnaud model of open pneumothorax. After application of the vented seals (nine each of SCS, ACS, and BCS), a hypothermia-prevention blanket was placed over the swine and 1,600 mL of air was injected into the thoracic cavity. Mean arterial pressure (MAP) decrease was measured during the injection period, and injection was discontinued (venting failure) if the MAP decreased by 20% from baseline. Skin adhesion: Seals (SCS, ACS, BCS, and HCS) were placed on the skin of five diaphoretic able-bodied volunteers to simulate potential prehospital conditions. After a 15-minute wear period, which included controlled movements, to simulate field transport, the total force required to remove the dressing was measured using an Instron Tensiometer. **Results.** Venting function: No SCS and BCS applications failed at the 20% MAP decrease threshold, whereas all ACS air injections were discontinued after reaching the threshold. The decreases in MAP from baseline for the SCS, ACS, and BCS were 1.8%, 9%, and 26.5%, respectively. The SCS was statistically superior to the ACS ($p < 0.001$) and the BCS ($p < 0.05$) using single-factor analysis of variance, 95% confidence level. Skin adhesion: The ACS and the BCS failed to remain on the skin after the wear period, so adhesion force could not be measured. The SCS and the HCS demonstrated mean adhesion values of 149.6 and 60.0 oz, respectively ($p < 0.005$). **Conclusion.** In this study, the new SCS was functionally superior to the current commercial products for venting and skin adhesion.

92. Does EMS-Perceived Anatomic Injury Predict Trauma Center Need?

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Objectives. To determine the predictive value of the anatomic step of the 2006 Field Triage Decision Scheme for identifying trauma center need and to determine the accuracy of emergency medical services (EMS)-perceived injury compared with injuries identified at hospital discharge. **Methods.** EMS providers caring for injured adults transported to regional trauma centers in three mid-sized communities were interviewed over two years. Patients were included regardless of injury severity. The interview was conducted upon emergency department (ED) arrival and collected physiologic condition and anatomic injury. Patients who met the physiologic criteria were excluded. Trauma center need was defined as nonorthopedic surgery within 24 hours, intensive care unit admission, or death prior to hospital discharge. *International Classification of Diseases, Ninth Revision* (ICD-9) and external-cause-of-injury codes (E-codes) were assigned by billing personnel after hospital discharge. Data were analyzed by calculating descriptive statistics, including positive likelihood ratios (+LRs). **Results.** 11,892 interviews were conducted. One was excluded because of missing outcome and 1,262 were excluded because they met the physiologic step. EMS providers identified 1,169 cases that met the anatomic criteria, of which 308 (26%) needed the resources of a trauma center (38% sensitivity, 91% specificity, +LR 4.3; confidence interval [CI]: 3.9–4.8). Criteria with a +LR >5 were flail chest (8.9; CI: 4.1–19.2), paralysis (6.8; CI: 4.1–11.1), two or more long bone fractures (6.4; CI: 4.5–9.0), and amputation (6.1; CI: 1.5–24.2). Criteria with a +LR >2 and <5 were penetrating injury (4.8; CI: 4.1–5.5)

totaled 449, with vascular access obtained on 264 (59%), with 249 peripheral intravenous lines and 26 intraosseous lines being established. Prehospital hypothermia prevention was employed in 320 (71%) casualties. Incorrectly performed interventions included: three airway interventions, two chest procedures, 15 hemorrhage control, 16 vascular access, and one hypothermia prevention measure. 209 missed LSIs were identified, including 33 airway interventions, 12 chest procedures, 18 hemorrhage control, 107 vascular access, 24 hypotensive resuscitation, and 15 hypothermia prevention opportunities. **Conclusion.** This is the largest study of prehospital interventions performed in a combat zone. The most common incorrect LSIs included: chest procedures 7% (2/30), airway 6% (3/52), and vascular access 6% (16/264). The most common missed LSIs were airway 39% (33/85), chest procedures 29% (12/42), and vascular access 29% (107/371).

97. A Comparison of Three Commercially Available Vented Chest Seals for Prevention of Tension Pneumothorax in a Communicating Pneumothorax Porcine Model

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Introduction. Tension pneumothorax accounts for 3–4% of all combat casualties and is a significant source of preventable death. A communicating pneumothorax may allow preferential air into the thoracic wound vice the trachea, resulting in respiratory arrest and death from tension pneumothorax. The Committee on Tactical Combat Casualty Care (CoTCCC) recommends placement of an unvented chest seal over a communicating pneumothorax to prevent respiratory compromise. **Objective.** We conducted a randomized controlled study funded by the U.S. Navy Bureau of Medicine and Surgery to evaluate the efficacy of three commercially available vented chest seals. The primary endpoint was development of a tension pneumothorax after seal application. **Methods.** Research data derived from an approved Naval Medical Center, Portsmouth, VA, institutional animal care and use committee (IACUC) protocol. A communicating pneumothorax was created via surgical thoracostomy in 24 anesthetized Yorkshire swine (*Sus scrofa*). A 10-mL syringe barrel was cut to 3 cm and inserted into the wound with plunger in place, to seal the chest. Air was introduced into the chest cavity to a maximum volume of 50 mL/kg until a hemodynamically significant tension pneumothorax developed. Significance was defined as a drop in mean arterial pressure (MAP) by 20% or an increase in heart rate by 20%. After tension pneumothorax evacuation was completed, one of three vented chest seals was applied over the wound (HyFin $n = 8$, Sentinel $n = 8$, SAM $n = 8$) and air was injected to a maximum of 50 mL/kg. A 10% autologous blood infusion and a third 50-mL/kg air bolus were then introduced. All interventions were separated by a 15-minute rest period. If subjects survived the final 15-minute observation period, they were considered survivors. Ultrasound images were recorded after all interventions. **Results.** 29.0 ($\pm$11.5) mL/kg of air resulted in a hemodynamically significant tension pneumothorax during the control phase. All three chest seals effectively evacuated air and blood from the chest cavity. No significant hemodynamic compromise developed after air introduction with a vented chest seal in place. **Conclusion.** The HyFin, SAM, and Sentinel vented chest seals offer equal efficacy with regard to evacuation of blood and air in a communicating pneumothorax model. All three may offer prevention of a tension pneumothorax after penetrating thoracic trauma in combat.

98. Prehospital-Initiated Nontransport to the Emergency Department: A Descriptive Analysis of Outcome

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Introduction. Prehospital/emergency medical services (EMS) system utilization is increasing, which has prompted an examination of the appropriate use of ambulance transport, and various means to decrease EMS system stress. One such possibility is prehospital-initiated nontransport (PINT) to emergency departments (ED). Prior studies have either indicated over- or undertriage with no consistent outcome measures. **Objective.** To review if an established PINT policy can determine which patients do not require ambulance transportation to the ED by identifying those whose medical care does not necessitate further emergent evaluation. **Methods.** A review of a preexisting EMS quality assurance database for a one-month period was examined for nontransport. Patients who refused transport and those who had cardiac arrests with field discontinuation were excluded. This data set was then compared with the electronic health records (EHRs) of the major destination receiving facility (an academic medical center and its affiliates) to evaluate nontransported patients' next medical encounter in the next 30 days. Descriptive statistics were calculated for patient dispositions for those re-presenting for medical care within 24, 48, and 72 hours after the initial PINT. **Results.** During the study period, 451 PINT record patients were compared with available EHR records. 300 (66.51%) PINT records had entries available in the EHR. At 30-day follow up, 203 (67.7%) had a record of representation for medical care, with 81 (39.9%), 100 (49.3%), and 116 (57.1%) presenting within 24, 48, and 72 hours, respectively. Of these, inpatient admission occurred for 21 (10.34%), 26 (12.8%), and 27 (13.3%), respectively. Two were admitted for operative intervention and one for inpatient psychiatric care. No patients required admission to an intensive care unit. **Conclusion.** Although largely limited by loss to follow-up of PINT patients, this study suggests that a significant proportion of PINT patients still required hospital care and may have been more appropriate for ambulance transport to the ED. Further investigation with a larger comparison cohort of transported vs. nontransported patient outcomes is necessary to further determine the safety of PINT.

99. Which Emergency Medical Dispatch Codes Predict High Prehospital Nontransport Rates in an Urban Community?

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Introduction. The Medical Priority Dispatch System (MPDS) is an emergency medical dispatch (EMD) system that is widely used to prioritize 9-1-1 calls and optimize resource allocation. MPDS is a computer-based EMD system that uses callers' responses to scripted questions to categorize cases into groups, called *determinants,* based on complaint and perceived acuity. This system is used to generate priority codes that determine both the number and the speed of emergency medical services (EMS) resources that respond to 9-1-1 calls. **Objective.** To determine which MPDS dispatch codes are associated with high prehospital nontransport rates (NTRs). **Methods.** All unique MPDS call determinants from 2009 were sorted according to highest NTRs. All determinants with less than 10 annual calls were not included. MPDS groups (e.g., Traffic/Transportation Accidents) that included multiple determinants (e.g., injuries, pinned victims) with NTRs exceeding 25% were then identified and each determinant was analyzed regardless of nontransport rates. **Results.** EMS responded to a total of 43,327 calls in 2009, of which 5,352 did not involve transport by EMS (including 344 unique determinants). Forty unique determinants were identified to have a 25% or greater NTR, 12 exceeded 35%, four exceeded 45%, and only two were 50% or greater. Of the 12 exceeding 35%, four MPDS groups were identified: Assault/Sexual Assaults (4/12), Traffic/Transportation Accidents (4/12), Choking–Breathing (2/12), and Eye Problems/Injuries (2/12). Choking–Breathing (11A1) with a Non-Emergency Response had the highest nontransport rate, 57.9%. **Conclusion.** "Choking–Breathing" (with the lowest possible priority dispatch) had the highest overall NTR. The MPDS groups Traffic/Transportation Accidents and Assault/Sexual Assaults had the most determinants with NTRs exceeding 25%. Of the 40 highest NTRs, "Bravo" priorities were the most common (18/40). Many groups showed low NTRs, including pregnancy, breathing problems, and abdominal pain–related determinants.

100. Safety and Operational Innovation: Integrating Global Best Practice and Interdisciplinary Technical Expertise into Ambulance Design

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Introduction. Ambulance design has fundamentally not changed in 50 years. Historically and to date in the United States, ambulance design is the domain of health care providers, and input from technical science of automotive safety and operational ergonomics expertise has been limited at best. **Methods.** In this study, an interdisciplinary team integrating technical expertise from automotive engineering, operational ergonomics and human factors, clinical emergency medical services (EMS) and patient transport, epidemiology, and ambulance manufacturing was assembled. Identification and analysis of ambulance design from six countries was conducted over 24 months, with hands-on inspection of 179 different ambulance vehicle types and configurations. The strengths and weaknesses of each design were assessed based on technical principles of human biomechanical tolerances and vehicle dynamics. The optimal features were integrated into the design of two ambulance fleets, the first in Dallas, Texas, USA, and the second in Oslo, Norway. **Results.** The vehicles developed were built into an original equipment manufacturer (OEM) van that had met stringent global safety and operational performance testing, and that had electronic stability control. Interior design was configured around range of reach and operational task analysis, with rotatable forward- and rear-facing seating and no squad bench. Head-impact hazards were reduced with creative use of portable equipment go-bags that minimized the need for extensive cabinetry. Positioning of heavy equipment was low in exterior compartments to minimize back injury. Overall cost was less than that of the standard current ambulance vehicle in each service. These fleets were developed by innovative EMS and medical transport services and ambulance manufacturers. There are substantive cultural obstacles relating to conceptual change that exist in many services that would need to be addressed for broad-based dissemination. **Conclusion.** Ambulance design is a complex integration of the technical realms of a number