Highlights From the American Heart Association's 2019 Resuscitation Science Symposium

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T he American Heart Association's 2019 Resuscitation Science Symposium (ReSS), was held November 16 to 17, 2019 in Philadelphia, PA. ReSS provides an opportunity for scholars to present, exchange ideas, and discuss the latest research results and scientific developments in the field of resuscitation science. A total of 62 oral presentations and 220 posters over 16 sessions including population health initiatives, clinical research and basic science were presented.[1]

AWARDS

The Young Investigator Awards were presented to 11 investigators within the first 5 years of their appointments, recognizing outstanding contributions to research in resuscitation science research. Table S1 provides names and research titles of awarded researchers.

The Lifetime Achievement Award in Cardiac Resuscitation Science was presented to Rudolph W. Koster, MD, from the Academic Medical Center, Amsterdam, The Netherlands Dr. Koster's research has advanced initial care for out-of-hospital cardiac arrest (OHCA). Dr. Koster's early work focused on the evaluation of patients presenting with chest pain, but later in his career, his focus moved toward OHCA. His extensive body of literature has defined the role of automatic external defibrillators (AEDs), ensuring the delivery of prompt and effective resuscitation efforts for patients in OHCA. He has played a central role in creating cardiac arrest and resuscitation guidelines in both the United States and Europe.

The Ian G. Jacobs Award for International Group Collaboration to Advance Resuscitation Science was presented to the World Restart a Heart initiative, a global campaign to increase awareness about the importance of bystander cardiopulmonary resuscitation (CPR) and to increase bystander CPR rates worldwide.

The ReSS Champion Award for contributions to the field through research and clinical improvements in government, industry, or public advocacy was awarded to Jane D. Scott, ScD, MSN, currently the director, Division of Cardiovascular Sciences, Office of Research and Training and Career Development from the National Heart, Lung, and Blood Institute, Rockville, MD. She helped create the current Trans NIH K12 Program in Emergency Care Research that was released in 2015 and funds 4 research centers. Dr. Scott has worked

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in a variety of research, research training, and clinical settings pertaining to emergency and trauma care and has served on numerous state and federal research and technical advisory panels, including the national advisory committee for the Robert Woods Johnson Foundation's Urgent Matters Program to reduce emergency department crowding 2002–2004.

The Max Harry Weil Award for Resuscitation Science was presented to Quinjun Yu, MD, PhD, from the University of Iowa Hospitals and Clinics, Iowa City, IA, for work on the mechanistic role of BolA Family Member 3 in pulmonary hypertension.

This year's best Oral Abstract Awards were presented to Per Nordberg, MD, PhD, Jason Lesnick, MD, Tulasi Jinka, DVM, PhD, and Kelley R. Branch MD, MS. Dr. Nordberg presented a secondary analysis of data from the PRINCESS (Prehospital Resuscitation Intra Nasal Cooling Effectiveness Survival Study) trial[2] showing higher rates of survival with good neurological survival in patients with an initial shockable rhythm who received early intra-arrest cooling. Dr. Lesnick also presented a secondary analysis of trial data, demonstrating an association between airway insertion first-pass success with return of spontaneous circulation and survival at 72 hours in out-of-hospital cardiac arrest. Dr. Jinka presented his findings that high-dose, intranasal insulin in a rat model of cardiac arrest improved neurological recovery and caused rapid activation of brain Akt (Akt protein kinase) survival signaling. Dr. Branch showcased the findings of the CT-FIRST (CT-FIRST: Cardiac Computed Tomography Versus Stress Imaging For Initial Risk Stratification) study, which explored the role of coronary computed tomography angiography in the diagnosis of significant coronary artery disease in patients with out-of-hospital cardiac arrest.

WOMEN IN RESUSCITATION SCIENCE NETWORKING MEETING

This event was attended by more than 40 women resuscitation scientists spanning early career investigators to the most senior leaders in the field of resuscitation science. Led by co-chairs, Dr. Katherine Berg and Dr. Anne Grossestreuer from Beth Israel Deaconess Medical Center, Boston, MA, the event was structured as a roundtable discussion addressing topics such as mentorship, sponsorship, and gender bias in research. Although there were accolades for many of the programming opportunities that engaged women, women in resuscitation who attended were eager to see increased involvement of women as members of panels, as invited speakers, and as members of the programming committee for future ReSS meetings. On a separate note, women in resuscitation voiced concerns regarding institutional

promotion and networking. To target this specifically, leadership in attendance from the American Heart Association were eager to propose opportunities for women to remain in contact with each other by keeping their profile in the professional heart daily page at the American Heart Association current. This will serve as a novel opportunity for the association to further support communication among women to bolster sponsorship, networking, and future collaboration.

JAPANESE CIRCULATION SOCIETY AND AMERICAN HEART ASSOCIATION SESSION

ReSS hosted a joint lunch session with the Japanese Circulation Society titled "An update on automatic external defibrillators (AEDs) and public access defibrillation." Session moderators included Dr. Yoshio Tahara from the National Cerebral and Cardiovascular Center, Osaka, Japan, and Dr. David Gaieski from Jefferson University, Philadelphia, PA. To begin the session Dr. Katsutaka Hahiba presented current work organized by the Japanese Circulation Society on CPR training and AED training for citizens. The joint session highlighted examples of school-based trainings, mass layperson CPR training initiatives, and innovative methods to increase public awareness. As a follow-up, Dr. Audrey Blewer from Duke University School of Medicine, Durham, NC, discussed racial, ethnic, and socioeconomic disparities in AED training, use, and placement. Dr. Blewer demonstrated that Latinos are less likely than non-Latinos to receive AED training in the United States.[3] Additionally, she presented work suggesting variation in placement and use of AEDs by socioeconomic status.[4,5] Dr. Takahiro Nakashima from the National Cerebral and Cardiovascular Center, Osaka, Japan, discussed evidence of the importance of public access defibrillation from quantitative work conducted in Japan.[6] Dr. Justin Boutilier from the University of Wisconsin, Madison, WI, further reinforced the opportunity of drone-delivered AEDs.[7]

POPULATION HEALTH INITIATIVES

Epidemiologic and Outcomes-Based Resuscitation Science

Dr. Brian E. Granau from St Paul's Hospital, Vancouver, British Columbia, Canada, presented new analysis of the North American Resuscitation Outcomes Consortium demonstrating sex-based inequities in access and application of public access defibrillators. When women experience cardiac arrest in public spaces, they are less likely to have a public access defibrillator applied by a bystander (odds ratio, 0.83; 95% CI, 0.70–0.99).

Dr. Linn Andelius from the Emergency Medical Services Copenhagen, Ballerup, Denmark, shared how a dispatch citizen responder program and public access defibrillator registry improved survival in Denmark. Citizen responders to a smartphone application notification were equally likely to arrive before emergency medical services in both public and private locations. Among private OHCAs where bystander defibrillation was reported, 3 out of 4 were performed by citizen responders.

Dr. Sachin Argawal from Columbia University Medical Center, New York, NY, highlighted the need to understand better the heterogeneous subtypes of post-sudden cardiac arrest survivorship disabilities and to identify modifiable risk factors and potential ameliorating factors. In a prospective study, 1 out of 2 patients had 1 or more post-sudden cardiac arrest survivorship deficits (ie, cognitive impairment, disability in activities of daily living, depression, and posttraumatic stress disorder at hospital discharge).

Dr. Katherine Berg from Beth Israel Deaconess Medical Center Boston, MA, shared data from the GWTG-R (Get-With-The-Guidelines-Resuscitation) registry on trends in median CPR duration over time in patients with and without return of spontaneous circulation (ROSC) after in-hospital cardiac arrest. Between 2001 and 2017, there was a significant increase in median CPR duration in adult patients who did not achieve ROSC and a decrease in those who did attain ROSC. The increase in CPR duration in patients without ROSC has been associated with an increase in hospital survival over time. Table 1 provides a summary of oral presentations on Population Health Initiatives.

CLINICAL RESEARCH

The Potential for Extracorporeal Membrane Oxygenation and to Change the Paradigm

Five studies evaluating extracorporeal cardiopulmonary resuscitation (ECPR) for cardiac arrest resuscitation were presented. Dr. Jason Bartos from the University of Minnesota, Minneapolis, MN, presented single-center data from their series of over 168 patients examining the utility of diagnostic tools obtained within 24 hours of admission for neurologic prognostication among adult patients treated with ECPR. They found that the following tests were highly specific (≥98%) for poor neurologic outcomes (cerebral performance category ≥3) but were not sensitive (20–39%): cerebral edema or anoxic injury on admission computed tomography of the head, neuron specific enolase (NSE) >3×the upper limit of normal, absence of brainstem reflexes, or isoelectric electroencephalograph.

Dr. Matthew Alexander from University of Utah, Salt Lake City, UT, presented data from Dr. Scott Youngquist's group at the University of Utah, examining the role of early post resuscitation magnetic resonance imaging to quantify duration of brain ischemia in swine. Among 11 swine who underwent cardiopulmonary arrest and were resuscitated with ECPR, there was a strong linear correlation between duration of ischemia and change in gray and white matter apparent diffusion coefficient ($r=-0.87$, $=-0.79$; respectively).

Dr. Tia Raymond from Medical City Children's Hospital, Dallas, TX, presented data examining the relationship between quality of CPR before cannulation for ECPR, rather than duration of CPR, and patient outcomes. They examined 62 pediatric ECPR cases from a prospective observational study of in-hospital cardiac arrest among children from the Pediatric Resuscitation Quality Collaborative sites. Older patients and longer CPR duration were associated with lower survival to hospital discharge, whereas quality of CPR (rate, depth, and compression fraction) was not associated with outcomes.

Dr. William Chancellor from the University of Virginia, Charlottesville, VA, presented novel data on the use of an adenosine 2A receptor agonist, which modulates inflammation, to influence survival at 24 hours among swine who underwent cardiac arrest followed by ECPR. Among 5 swine randomized to receive an

Table 1.   Summary of Oral Presentations on Population Health Initiatives[1]

Epidemiologic and Outcomes-Based Resuscitation Science		
Lecture	Presenter	Country
Public Access Defibrillators: Sex-Based Inequities in Access and Application	Brian E. Grunau	Canada
Dispatched Citizen Responders Perform Three Out of Four of all Bystander Defibrillated Out-of-Hospital Cardiac Arrests in Residential Areas	Linn Andelius	Denmark
Cognitive, Psychological, and Functional Limitations After Sudden Cardiac Arrest Among a Racially and Ethnically Diverse United States Population	Sachin Agarwal	United States
Trends in Median CPR Duration Over Time in Patients with and Without Return of Spontaneous Circulation	Katherine M. Berg	United States

CPR indicates cardiopulmonary resuscitation.

adenosine 2A receptor agonist, 24-hour survival was 100% versus 40% in the 5 swine randomized to receive saline placebo.

Finally, Dr. Rajat Kalra from the University of Minnesota, Minneapolis, MN, presented data from the University of Minnesota ECPR group examining the change in echocardiographic function after resuscitation using ECPR. Among 58 adult ECPR patients who had >1 echocardiogram after resuscitation, the measured ejection fraction was greater (43% versus 18%) among patients successfully decannulated. They further posit that changes in myocardial loading patterns were reflective of decreased transpulmonary flow and left ventricular preload rather than changes in afterload.

INTRA-ARREST MONITORING AND ASSESSMENT

Four invited presentations were delivered on topics related to intra-arrest assessment and physiologic monitoring during cardiac arrest. Dr. Robert Sutton from the Children's Hospital of Philadelphia, Philadelphia, PA, presented a state-of-the art review on the use of physiologic monitoring during cardiac arrest including some of the latest studies supporting the use of hemodynamic targets to improve survival and neurological outcomes during CPR.[8] Dr. Sutton also presented data from a recent large multicenter study evaluating the impact of ventilation rates in pediatric arrest survival outcomes. The authors found that ventilation rates exceeding guideline recommendations were common and that among the range of rates delivered, higher rates were associated with improved survival to hospital discharge.[9]

Dr. Romolo Gaspari from the University of Massachusetts Medical School, Worcester, MA, presented a review of the rationale and latest supporting evidence on the use of echocardiography during cardiac arrest resuscitation, including the role of transthoracic and transesophageal echocardiography, identification of potentially reversible etiologies, characterization of myocardial activity, and prognosis informed by the presence of myocardial contractions. Dr. Gaspari described recent observational data indicating prolonged CPR pauses with the use of transthoracic echocardiography [10,11] and the potential of transesophageal echocardiography improving quality of resuscitation.[12,13]

Dr. Claudio Sandroni from the Catholic University School of Medicine, Rome, Italy, presented a review of the use of capnography during CPR. Real-time measurement of end-tidal expiratory pressure of carbon dioxide using capnography is a noninvasive estimation of cardiac output during CPR and can predict ROSC. While levels of end-tidal expiratory pressure of carbon dioxide <10 mm Hg has been consistently associated with poor prognosis, multiple factors can significantly affect the levels of end-tidal expiratory pressure of carbon dioxide and therefore it should not be used in isolation for decision making during resuscitation.[14]

Dr. Cornelia Genbrugge from the Hasselt University, Hasselt, Belgium, presented on the use of cerebral oximetry measured using near-infrared monitoring devices during CPR. Studies have shown that monitoring of cerebral saturation during CPR may be able to predict ROSC and neurological outcome and that it has the potential to help guide CPR interventions.[15]

NEUROLOGIC MONITORING AND PROGNOSTICATION

A plenary session discussed neurologic monitoring and prognostication in comatose postarrest patients. Dr. Jon Rittenberger from the Guthrie-Robert Packer Hospital, Sayre, PA, reviewed new research in electroencephalography (EEG) monitoring. Although malignant EEG patterns are common, the trajectory over time is associated with outcome, including in the first 24 hours.[16–18] One particular EEG pattern, myoclonic status epilepticus, has traditionally been associated with uniformly poor outcomes. However, patients demonstrating myoclonic status epilepticus with a reactive EEG background can have good neurologic outcome.[18]

Dr. Jonathan Elmer from the University of Pittsburgh, Pittsburgh, PA, provided a primer on pupillometry after resuscitation from cardiac arrest. Both quantitative and qualitative pupillometry is associated with survival and neurologic outcome.[19,20] Following these reviews of noninvasive monitoring methods, intracranial monitoring in the postarrest patient was reviewed by Dr. Soojin Park from Columbia University Medical Center, New York, NY. Changes in intracranial pressure are common after ROSC and have been associated with outcome. Although the data are limited to small cohorts, glucose, lactate, and pyruvate levels are also predictive of outcome.[21] Although these are indirect measures of brain tissue perfusion, brain tissue oxygenation can also be directly measured. It varies widely in postarrest patients and can be used to titrate oxygen delivery and mean arterial blood pressure goals.[22]

Finally, Dr. Sarah Perman from the University of Colorado School of Medicine, Aurora, CO, reviewed the literature supporting serum biomarkers for postarrest prognostication. Although no individual biomarker is sufficient to rule out a good outcome, NSE, S100b,

and Tau are very specific for poor outcomes.[23,24] Neurofilament light chain has demonstrated earlier release and demonstrates superior sensitivity and specificity in this population.[25]

MEASURING ISCHEMIA REPERFUSION INJURY AND PROGNOSTICATION

Five studies addressing ischemia reperfusion injury and prognostication during cardiac arrest resuscitation were presented during this oral abstract session. Dr. Jung Soo Park from the Chungnam National University, Daejeon, Republic of Korea, presented results from a single-center prospective study measuring serum and cerebrospinal fluid NSE levels in adult, comatose OHCA survivors treated with targeted temperature management. Levels were obtained on hospital arrival and at 24, 48, and 72 hours post ROSC. Investigators found higher levels of both serum and cerebrospinal fluid NSE levels in patients who had poor neurologic outcome (cerebral performance category 3–5 at 6-month) at each time point except the initial assessment. In this small cohort, cerebrospinal fluid NSE levels at 24 hours after ROSC were significant predictors and sensitive markers of 6-month poor neurologic outcome.

Dr. Norihiro Nishioka from the University of Kyoto, Kyoto, Japan, presented results from a prospective multicenter observational study investigating the association between serum lactate during CPR and survival from OHCA. Data on adult OHCA patients (n=3674) between 2013 and 2016 were included. Across 4 groups of patients, categorized based on lactate level obtained prior to ROSC, 1-month survival decreased stepwise as presenting lactate level increased. On subgroup analysis based on initial cardiac arrest rhythm, this trend continued for patients with nonshockable rhythm but not shockable rhythm.

Dr. David E. Hamilton from Massachusetts General Hospital, Boston, MA, presented results from a multicenter retrospective cohort (2017–2019, n=283) evaluating the prognostic value for NT-proBNP (N-terminal pro-B-type natriuretic peptide) in patients surviving OHCA. With increasing NT-proBNP level, mortality increased in a stepwise fashion across quartiles of patients. This relationship remained after adjusting for traditional confounders, suggesting that NT-proBNP may predict increased in-hospital mortality after OHCA.

Additionally, Dr. Hamilton presented results from a retrospective study characterizing the trend in high sensitivity troponin T for patients surviving OHCA. In 120 patients enrolled 2018–2019, high sensitivity troponin T was measured at baseline and then 1, 3, and 6 hours after OHCA. Investigators observed significantly higher high sensitivity troponin T levels in patients deemed to have had a cardiac cause for arrest. High sensitivity troponin T values rose over time for patient in both groups in this study.

Dr. Tomohisa Seki from the University of Tokyo Hospital, Tokyo, Japan, presented a study employing machine learning to develop a prediction model for 1-month survival and neurologic outcome after OHCA of presumed cardiac etiology. Data from a national Japanese registry between 2005 and 2016 were analyzed and divided into a training set and validation set. A total of 1 423 338 cases were available for analysis and 19 prehospital variables were used for modeling. Prediction modeling seemed possible with machine learning techniques, identifying patients who may have been successfully resuscitated.

INTERVENTIONS AND TRIALS: IMPROVING ARREST OUTCOMES

A session dedicated to clinical interventions to improve outcomes from cardiac arrest included 5 presentations. Dr. Jostein Brede from the St. Olav's Hospital, Trondheim, Norway, presented his work on resuscitative endovascular balloon occlusion of the aorta for OHCA, placed in the prehospital setting. The authors determined that the device was successfully deployed in all patients (n=10), with an 80% first-pass success rate, without interfering with high-quality advanced cardiac life support; ROSC was obtained in 6/10 patients.[26]

Dr. Steven Kronick from the University of Michigan, Ann Arbor, MI, presented data on intra-arrest pharmacologic interventions. This study explored the use of amiodarone versus lidocaine for in hospital cardiac arrest due to ventricular fibrillation or pulseless ventricular tachycardia, using data from GWTG-R. The authors found that over two thirds of the cohort received amiodarone (68.7%) and the remainder received lidocaine (31.3%). On multivariable regression, there was no difference in ROSC between amiodarone and lidocaine; however, lidocaine was associated with higher rates of survival and neurologic recovery.

Dr. Nicholas Johnson from the University of Washington presented work on postarrest targeted temperature management "dose." This single-center study compared outcomes for arrest patients treated with targeted temperature management after implementation of a protocol stipulating a goal temperature of 36°C. The authors compared the outcomes with a historical control cohort that was treated at 33°C. Investigators found that patients treated in the 36°C cohort had worse neurologically intact survival

to discharge neurologically intact (30%) compared with those treated at 33°C (40%), a benefit that was maintained after multivariable regression analysis.[27] The authors conclude that targeting a temperature of 33°C resulted in better outcomes than the protocol targeting 36°C for postcardiac arrest neurologic protection.

Dr. Pekka Jakkula from HUS Helsinki University Hospital, Helsinki, Finland, presented his findings on blood pressure targets after OHCA This project was a pooled post hoc analysis from the Neuroprotect (NCT02541591) and COMACARE (Carbon Dioxide, Oxygen, and Mean Arterial Pressure After Cardiac Arrest and Resuscitation; NCT02698917) trials. Subjects were randomized into cohorts of mean arterial pressure 65 mm Hg or 80/85 to 100 mm Hg targets in the first 36 hours of intensive care treatment. The primary outcome was NSE measured at 24, 48 and 72 hours in addition to neurological recovery as described by cerebral performance category. The investigators did not find any statistically significant differences between the 2 mean arterial pressure target cohorts with respect to NSE or neurologic recovery (50% in the 65 mm Hg mean arterial pressure group versus 56% in the 80/85–100 mean arterial pressure group, P=0.417).

Finally, Dr. Corina de Graf from the Amsterdam UMC, Academic Medical Center, Amsterdam, The Netherlands, presented her work on police AED use. The authors proposed that using a novel AED algorithm titled cprINSIGHT Analysis Technology, designed to allow for rhythm analysis with compressions in progress, would result in reduced interruptions in CPR and higher chest compression fraction. Investigators compared cases from 2016 (preintervention of cprINSIGHT) to cases from 2018 that employed the novel technology. The primary outcome measured was preshock pause and median chest compression fraction. Investigators determined that postintervention subjects had significantly shorter preshock pauses (7 seconds versus 22 seconds, P<0.001) and a significantly higher chest compression fraction compared with the preintervention cohort (87% versus 77%, P<0.001). Table 2 provides a summary of oral presentations on Clinical Research.

LATE BREAKING ABSTRACTS IN RESUSCITATION SCIENCE

A session dedicated to present late breaking abstracts included presentations of 5 major studies, with topics ranging from basic science to CPR training.

Dr. Mathias Johan Holmberg from Aarhus University Hospital, Denmark, presented on the use of epinephrine during pediatric bradycardia leading to arrest. Data from >6700 pediatric arrest cases (2000–2018), with initial non-pulseless bradycardia, were analyzed using time-dependent propensity score matching, concluding that epinephrine was associated with worse outcomes in children receiving CPR for bradycardia with poor perfusion.[28]

Dr. Ari Moskowitz from Beth Israel Deaconess Medical Center, Boston, MA, presented results from a randomized controlled trial (n=80) investigating the use of rocuronium neuromuscular blockade for postcardiac arrest patients versus usual care, with primary outcome of change in lactate from baseline to 24 hours. Findings showed early, continuous neuromuscular blockade did not reduce lactate levels over the first 24 hours postarrest versus usual care.

Dr. Lorrel Brown from the University of Louisville, Louisville, KY, presented data from a comparison of a novel, interactive CPR training film versus standard CPR training for high school students. Utilizing an educational modality incorporating film of a realistic simulation of a cardiac arrest event in a school, students were found to have significantly greater CPR skills retention when compared with standard training.

Dr. Brian Weil from the University of Buffalo, Buffalo, NY, presented data on the effects of nanoparticle formulations of triiodothyronine (T3) in a porcine arrest model. The investigation demonstrated higher ROSC rates in animals receiving T3 nanoparticles versus epinephrine, highlighting T3 as a promising area of further investigation.

The session concluded with a presentation by Dr. Matthew Maggio from Rosalind Franklin University of Medicine and Science, North Chicago, IL, on the use of vasopressin infusion in a swine model with concurrent hemorrhagic shock and traumatic brain injury (TBI). Building on previous results that demonstrated early and sustained vasopressin infusion and restricted fluids improves survival in a swine model with liver laceration, Maggio and team investigated a similar approach in a porcine model with concurrent hemorrhagic shock and TBI. Investigators found that vasopressin infusion and restricted fluids improved 72-hour survival.

YEAR IN REVIEW

Dr. Robert Neumar from the University of Michigan, Ann Arbor, MI, highlighted the key original cardiac arrest studies from the prior year. Studies presented included the areas of intra-arrest[2,9] postcardiac arrest care,[29–34] neuroprognostication,[19,25,35] and basic science.[36] Table S2 provides a summary of the selected studies.

Table 2.   Summary of Oral Presentations on Clinical Research[1]

The Potential for ECMO and E-CPR to Change the Paradigm		
Lecture	**Presenter**	**Country**
Early Neuroprognostication After Refractory VF/VT Cardiac Arrest Requiring ECPR	Jason A. Bartos	United States
Early Magnetic Resonance Imaging to Quantify Ischemic Brain Insult Early Following Cardiac Arrest in a Swine Model	Matthew D. Alexander	United States
Outcomes After Pediatric Extracorporeal Cardiopulmonary Resuscitation: Do Quantitative CPR Metrics Matter?	Tia Tortoriello Raymond	United States
Adenosine Receptor Activation During Extracorporeal Cardiopulmonary Resuscitation Improves Survival After Cardiac Arrest in Swine	William Z. Chancellor	United States
Echocardiographic Evaluation of Left Ventricular Recovery After Refractory Out-of-Hospital Cardiac Arrest	Rajat Kalra	United States
Intra-Arrest Monitoring and Assessment		
Lecture	**Presenter**	**Country**
Intra-Arrest Physiologic Monitoring	Robert M. Sutton	United States
The Role of Transthoracic and Transesophageal Ultrasound	Romolo J. Gaspari	United States
Capnography During CPR	Claudio Sandroni	Italy
Near-Infrared Monitoring During CPR	Cornelia Genbrugge	Belgium
Neurologic Monitoring and Prognostication		
Lecture	**Presenter**	**Country**
EEG for Post-Arrest Assessment	John C. Rittenberger	United States
Quantitative Pupillometry After Cardiac Arrest	Jonathan Elmer	United States
Brain Physiologic Data and Outcomes from Arrest	Soojin Park	United States
Serologic Markers of Brain Injury	Sarah M. Perman	United States
Measuring Ischemia Reperfusion Injury and Prognostication		
Lecture	**Presenter**	**Country**
The Usefulness of Neuron-Specific Enolase in Cerebrospinal Fluid to Predict Neurological Prognosis in Cardiac Arrest Survivors Who Underwent Target Temperature Management: A Prospective Observational Study	Jung Soo Park	Korea
Association Between Serum Lactate During Cardiopulmonary Resuscitation and Survival in Adult Out-of-Hospital Cardiac Arrest: A Multicenter Cohort Study (The Critical Study in Osaka, Japan)	Norihiro Nishioka	Japan
Prognostic Role of NT-ProBNP in Out-of-Hospital Cardiac Arrest	David E Hamilton	United States
Prevalence and Pattern of Myocardial Injury in Patients with Cardiac vs Non-Cardiac Cause of Out-of-Hospital Cardiac Arrest: A One-Year Multicenter Clinical Experience with the High-Sensitivity Troponin T Assay	David E Hamilton	United States
Machine Learning Models for Outcome Prediction of Out-of-Hospital Cardiac Arrest of Presumed Cardiac Cause Using the All-Japan Utstein Registry	Tomohisa Seki	Japan
Interventions and Trials: Improving Arrest Outcomes		
Lecture	**Presenter**	**Country**
Feasibility and Safety of Pre-Hospital Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in NonTraumatic Out-of-Hospital Cardiac Arrest[26]	Jostein R. Brede	Norway
Comparison of Amiodarone versus Lidocaine for Treatment of In-Hospital Cardiac Arrest	Deborah S. Wagner	United States
Targeted Temperature Management at 33 versus 36 Degrees: Outcomes After Real-World Implementation[27]	Nicholas J. Johnson	United States
Low Versus High Blood Pressure Targets After Out-of-Hospital Cardiac Arrest[31]	Pekka Jakkula	United States
Chest Compression Fraction Increased When Police Used AED That Analyses Heart Rhythm During CPR	Corina de Graaf	The Netherlands

AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; ECMO, extracorporeal membrane oxygenation; ECPR, extracorporeal cardiopulmonary resuscitation; EEG, electroencephalograph; NT-proBNP, N-terminal pro-B-type natriuretic peptide; VF, ventricular fibrillation; and VT, ventricular tachycardia.

SPECIAL PRESENTATION: THE EXCELLENCE IN PREHOSPITAL INJURY CARE TRAUMATIC BRAIN INJURY STUDY: RESULTS AND IMPLICATIONS

Dr. Daniel Spaite from the University of Arizona, Arizona, AZ, presented the results from the EPIC (Excellence in Prehospital Injury Care) TBI study,[37] a controlled, before-after, multisystem investigation conducted in Arizona. Survival to discharge (primary outcome) and survival to admission were compared before and after implementation of prehospital TBI guidelines emphasizing avoidance/treatment of hypoxia, prevention/correction of hyperventilation, and avoidance/treatment of hypotension. The investigators found significant association between prehospital TBI guideline implementation and improvement of overall survival to admission but not with significant improvement of overall survival to discharge. However, adjusted survival tripled in intubated patients with severe TBI.

BASIC SCIENCE

Laboratory and Translational Studies: Arrest and Ischemia Reperfusion Injury

Basic science oral abstract presentations utilized laboratory models of cardiac arrest and ischemia-reperfusion injury.

Dr. Renaud Tissier and Dr. Emilie Boissady from Ecole Nationale Veterinaire d'Alfort, Maisons-Alfort, France, studied early inflammatory response and whether total liquid ventilation (TLV) could attenuate the postarrest inflammatory cascade. Rabbits were anesthetized and subjected to 10 minutes Ventricular fibrillation rhythm and then assigned to either normothermic (n=6), TLV (n=6), or sham (n=5) group. TLV was utilized for cooling induction for 20 minutes and then external cooling was maintained for 3 hours. Survival and neurological recovery were assessed at 3 days, which showed improvement in the TLV group compared with controls. Histological examination showed an attenuation of neural degeneration in specific brain loci. Cytometry analysis showed benefit of TLV attributed to the delay in immune peripheral cell activation and cytokine release, indicating the most benefit of TLV was in the early but not late injury cascade by reducing the cellular migration and neuroinflammation through preservation of the blood–brain barrier.

Dr. Claudius Balzer, from Vanderbilt University, Nashville, TN, studied the use of waveforms from a standard peripheral intravenous line to determine cardiac and volume status and detect ROSC without pauses in chest compression in a rat model. Animals were intubated, ventilated, and cannulated with 24 g peripheral tail intravenous line and 22 g femoral artery intravenous line. Cessation of mechanical ventilation precipitated arrest; after 8 minutes, CPR was commenced with chest compression of 1.5 cm and rate of 200/min. Waveforms were assessed using Fourier transformation of the peripheral venous waveform. Within 8 seconds of a reduction in the waveform, there was a rapid increase in the end-tidal CO_2 associated with ROSC. In all rats, there was an inverse relationship between peripheral intravenous analysis waveform and end-tidal CO_2, thereby detecting ROSC without interruption of CPR for pulse checks.

Dr. Guanghui Zheng, from the Weill Institute, Richmond. VA, studied MCC950, a highly selective inhibitor of NLRP3 inflammasome known to mediate myocardial and cerebral ischemia reperfusion injury. Fifteen male Sprague-Dawley rats were equally randomized into the MCC950 intervention, control, or sham groups. The rats were subjected to ventricular fibrillation arrest for 6 minutes, followed by 8 minutes CPR and 4J defibrillation. After ROSC, either MCC950 or a vehicle was administered intraperitoneally. Sublingual microcirculation and ejection fraction were measured at baseline, 3, 6, and 48 hours after ROSC and were found to be significantly greater in the MCC950 group compared with the control group in all time points. Neurological deficit score was measured at 48 hours post ROSC and was improved in the MCC950 compared with controls. Survival was greater in the MCC950 group (4/5 versus 1/5, $P<0.05$).

Table 3. Summary of Oral Presentations on Basic Science[1]

Laboratory and Translational Studies: Arrest and Ischemia Reperfusion Injury		
Lecture	**Presenter**	**Country**
Ultra-Fast Cooling Induced by Total Liquid Ventilation Provides Neuroprotection Through a Delay in the Acute Systemic Inflammatory Response After Cardiac Arrest in Rabbits	Renaud Tissier	France
Peripheral Intravenous Analysis Detects Return of Spontaneous Circulation Without Interruption of Chest Compressions in a Rat Model of Cardiopulmonary Resuscitation	Claudius Balzer	United States
Effects of the Selective NLRP3-Inflammasome Inhibitor MCC950 on Post-Resuscitation Myocardial and Cerebral Function in a Rat Model of Cardiopulmonary Resuscitation	Guanghui Zheng	United States
Poloxamer 188 Protects Mouse Brain Microvascular Endothelial Cells in an in-vitro Traumatic Brain Injury Model	Felicia P. Lotze	Germany

Dr. Felicia P. Lotze, from the University of Greifswald, Greifswald, Germany, studied simulated ischemia reperfusion injury as well as compression-type TBI in mouse brain microvascular endothelial cells and evaluated to determine whether Poloxamer 188 (P188) would protect the cells from these 2 injury types. Microvascular endothelial cells cells were subjected to either normoxic or hypoxic conditions for 5 hours as well as compression for the first hour, followed by 2 more hours of reoxygenation in normoxic conditions plus either 1 of 3 concentrations of P188 (10 μmol/L, 100 μmol/L, 1 mmol/L) or no P188. In hypoxic cells, P188 increased metabolic activity at all concentrations. In hypoxic compressed cells, cell number did not change with P188 concentrations; however, there were greater benefits of increased metabolic activity and decreased cytotoxicity with increasing P188 concentrations. Table 3 provides a summary of oral presentations on Basic Science.

SOCIAL MEDIA IMPACT OF RESS 2019

Social medial played a leading role at ReSS 2019, allowing conference attendees to share and discuss the cutting-edge science as it was presented. Social media activity including the hashtag #ReSS2019 was assessed using social medial analytics (Symplur LLC, Upland, CA). Over 1500 tweets were sent over the 3-day conference, making over 5 million impressions worldwide.

CONCLUSION

The 2019 Resuscitation Science Symposium gathered resuscitation science researchers from around the world, who presented and discussed the latest in cardiac arrest research, spanning a wide spectrum of investigations from basic science to clinical trials and public health interventions.

ARTICLE INFORMATION

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Supplementary Materials

Tables S1–S2
References 1, 2, 9, 19, 25, and 29–36

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SUPPLEMENTAL MATERIAL

Table S1. ReSS 2019 Young Investigator Awards[1].

Young Investigator Awardee	Research Title
Linn Andelius	Dispatched Citizen Responders Perform Three Out of Four of All Bystander Defibrillated Out-of-hospital Cardiac Arrests in Residential Areas
Jesse Chan	Role of The Resuscitation Champion on Survival Outcomes for In-hospital Cardiac Arrest
William Z. Chancellor	Adenosine Receptor Activation During Extracorporeal Cardiopulmonary Resuscitation Improves Survival After Cardiac Arrest in Swine
Ryan A. Coute	National Institutes of Health Research Investment for The Leading Causes of Disability-adjusted Life Years in The United States
Rajat Kalra	Echocardiographic Evaluation of Left Ventricular Recovery After Refractory Out-of-hospital Cardiac Arrest
Pavitra Kotini-Shah	Sex Differences in Outcomes for Out-of-hospital Cardiac Arrest
Norihiro Nishioka	Association Between Serum Lactate During Cardiopulmonary Resuscitation and Survival in Adult Out-of-hospital Cardiac Arrest: A Multicenter Cohort Study (The Critical Study in Osaka, Japan)
Caitlin E. O'Brien	End-Tidal CO_2 -Guided Chest Compression Delivery Improves Survival in a Pediatric Model of Respiratory Failure and Cardiac Arrest
Jung Soo Park	The Usefulness of Neuron-specific Enolase in Cerebrospinal Fluid to Predict Neurological Prognosis in Cardiac Arrest Survivors Who Underwent Target Temperature Management: A Prospective Observational Study
Alexis Steinberg	Are Providers Overconfident in Predicting Outcome After Cardiac Arrest?
Robert D. Stevens	A Machine Learning-based Prediction of Cardiac Arrest Outcome Using A Large Multi-Center Database

Table S2. Summary of Selected Studies 2019 ReSS Year in Review.

Area	Study	Topic	Conclusions
Intra-arrest	Sutton et al[9]	Ventilation rates for pediatric in-hospital cardiac arrest	Ventilation rates in pediatric cardiopulmonary resuscitation need to be re-evaluated
	Norberg et al (PRINCESS)[2]	Intra-arrest intranasal cooling	Intra-arrest intranasal evaporative cooling does not improve overall survival with good neurologic function in bystander witnessed OHCA, but may benefit subpopulations such as those with initial shockable rhythm
Post-cardiac arrest care	Jakkula et al (COMACARE)[31]	High-normal vs low-normal $PaCO_2$ and PaO_2	Post-cardiac arrest normoxia, normocarbia, and normotension are reasonable. Studies are needed to evaluated individualized goal-directed strategies
		Moderate hyperoxia vs normoxia	
	Jakkula et al (COMACARE)[32]	Low-normal vs high normal mean arterial pressure	
	Ameloot et al[29]	Low-normal vs high-normal mean arterial pressure	
	Lemkes et al (COACT)[34]	Coronary angiography after cardiac arrest without STEMI	Immediate post-cardiac arrest percutaneous coronary intervention for patients without STEMI criteria does not improve survival in a population with low incidence of acute coronary occlusion
	Francois et al[30]	Prophylaxis antibiotics after cardiac arrest	Empiric antibiotics prevented early ventilator associated pneumonia in post-cardiac arrest patients treated with hypothermic targeted temperature management (TTM) but did not improve their survival
	Lascarrou et al (HYPERION)[33]	TTM for cardiac arrest with non-shockable rhythm	TTM at 33°C improves survival with good neurologic function compared to TTM at 37°C in post-cardiac arrest patients with non-shockable initial rhythm
Neuroprognostication			

	Scarpino et al (ProNeCA)[35]	Prediction of poor neurological outcome within 24 hours after cardiac arrest with SSEP, EEG, and head CT	Reliable neuroprognostication of futility within 24 hours of return of spontaneous circulation may be feasible using a multimodal approach
	Moseby-Knappe et al[25]	Serum neurofilament light chain for prognosis after OHCA	
	Oddo et al[19]	Quantitative vs standard pupillary light reflex for early prognostication in comatose cardiac arrest patients	
Basic science	Vrselja et al (Brain-*Ex*)[36]	Restoration of brain circulation and cellular functions hours post-mortem in swine	Brain-*Ex* has challenged the limits of total brain ischemia after which restoration of brain function can be achieved