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TITLE:
“Intraosseous Erythropoietin for Acute Tissue Protection in Battlefield Casualties Suffering Hypovolemic Shock”

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The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.
The project compared in a swine model of hemorrhagic shock (HS) the effects of vasopressin (VP) infusion and low-volume fluid resuscitation using normal saline (NS) on 72 hour survival, with erythropoietin (EPO) administration and HS severity as confounders. Twenty-four male pigs (36-41 kg) were anesthetized with isoflurane and nitrous oxide in oxygen and instrumented to assess hemodynamic function and advance a 23-F cannula into the right atrium for blood withdrawal (BW) and blood reinfusion using a custom developed system that allowed modeling spontaneous bleeding as a mono-exponential decay function. Twenty-four pigs were randomized 2:1 to receive an intraosseous infusion of VP (0.04 U/kg·min−1) or vehicle control starting 7 minutes into BW until the start of blood reinfusion at minute 210. Pigs were also randomized 1:1 to receive NS (half the amount of BW) or no fluids. Pigs assigned to VP were also randomized 1:1 to EPO (1,200 U/kg) or vehicle control and to have 65% or 75% of their blood volume withdrawn. Randomization proceeded by blocks ensuring balanced distribution in all the subsets. Survival analysis to 72 hours showed that survival was influenced by VP and NS but not by EPO or HS severity with the highest survival rate in the group VP-NS (100%) followed by VP-noNS (37.5%), noVP-NS (25%), and noVP-noNS (0%) with a high overall statistical significance (p=0.009 by the log-rank test) with each subset different than VP-NS by the Holm-Sidak’s test. Accordingly, these findings support an approach to the initial management of severe HS in the field that entails early initiation of VP infusion through the intraosseous route followed by low-volume fluid resuscitation (e.g., small boluses of normal saline).
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INTRODUCTION

Hemorrhagic shock after penetrating trauma in the battlefield accounts for a high percentage of potentially survivable injuries. A report on 4,596 battlefield fatalities between October 2001 and June 2011 in Operation Iraqi Freedom and Operation Enduring Freedom showed that 87% of such fatalities occurred before arrival to a medical treatment facility with 24% deemed potentially survivable. Of these potentially survivable injuries, 91% were associated with hemorrhage. Control of bleeding in compressible areas is highly effective and can save lives. However, severe hemorrhage can compromise vital organ perfusion and survivability. Fluid resuscitation is hemodynamically effective but is logistically constrained in the battlefield and not free of complications. In large quantities, fluids can precipitate coagulopathy by dilution and hypothermia and dislodge freshly formed clots. Similar considerations apply to hemorrhage associated with trauma in civilian populations. We have previously shown in a swine model of hemorrhagic shock – while investigating the effects of erythropoietin (EPO) – that vasopressin (VP) infusion promotes hemodynamic stability. During the reported period, we investigated whether VP infusion with or without low-volume fluid resuscitation using normal saline (NS) could improve survival from severe and protracted hemorrhagic shock produced by removing 65% or 75% of the animal’s blood volume. Consistent with the initial hypothesis of this project, i.e., that EPO could ameliorate tissue injury; we also included administration of EPO in this series.

BODY

The experiments were designed based on findings reported last year (after having completed three series of experiments) refocusing the work on the potential role of VP and low-volume fluid resuscitation for hemodynamic stabilization under conditions of severe hemorrhagic shock maintaining the emphasis on battlefield relevance and constraints for management in far-forward scenarios. Accordingly, we modified our hemorrhagic shock protocol as described below using the swine preparation depicted in Figure 1:

1. **Simulated bleeding pattern**: The pattern of acute blood loss was changed from a linear function to a mono-exponential decay function to more closely model bleeding after traumatic injury (i.e., high initial bleeding with progressively slower rates as blood pressure drops and hemostatic mechanisms are endogenously activated and/or externally applied). The approach involved additional software development by us that enabled entering any mathematical function of our choosing into our closed-loop system to drive the flow removal pattern with a precision of < 1 ml/min.

2. **Blood volume removed**: Two target levels of blood withdrawal (BW) were studied; 65% and 75% of the estimated blood volume. It is pertinent to highlight that in our previous hemorrhagic shock series the highest amount of BW was 65% of the blood volume. Thus, for the first time experiments were conducted withdrawing 75% of the estimated blood volume. The same mono-exponential decay function was used for both BW targets, stopping after 60 minutes for the BW 65% and after 80 minutes for BW 75%.

3. **Duration of hemorrhagic shock**: A long interval of hemorrhagic shock was studied to model a situation in which evacuation and arrival to a medical treatment facility from the initial injury is delayed for up to 3 and a half hour. Accordingly, the time for starting blood reinfusion (BR) was at 210 minutes from the start of BW.

Pursue of findings originated from the previous series prompted the change in the protocol as described below:

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**Abbreviations**

BR = Blood reinfusion  
EPO = Erythropoietin  
VP = Vasopressin  
NS = Normal saline  
BW = Blood withdrawal
**Vasopressin effect:** As reported previously, the addition of vasopressin infusion in a previous series dramatically improved initial resuscitation and subsequent 72-hour survival relative to a previous series in which only fluid resuscitation with normal saline (NS) was used for stabilization before BR. The effect of vasopressin on these outcomes was associated with higher cardiac index, prompting us to speculate that VP could act in part by enhancing venous return. Because these observations were made in separate series, the question regarding the efficacy and hemodynamic effects of VP could not be directly addressed. Accordingly, for this series animals were randomized 2:1 to VP or noVP. VP was infused intraosseously at a constant rate of 0.04 U/kg·min⁻¹ from minute 7 of BW to minute 210; i.e., the start of BR.

**Fluid resuscitation:** The preceding series also showed that in the presence of vasopressin, initial resuscitability and 72-hour survival could be achieved successfully administering a reduced amount of NS corresponding to half the amount of BW or no fluids at all. Thus, for the present series we examined whether NS could be required under the more severe hemorrhagic shock conditions modeled. The approach involved starting the series without fluid resuscitation and performing an interim analysis halfway through the series (i.e., after completion of 12 experiments) to assess the needs for fluid resuscitation. The interim analysis showed a 72-hour survival of only 3 of 12 animals (25%) prompting the inclusion in the second half of the series the administration of NS from minute 90 to minute 120 in amount corresponding to half the volume of BW. The relatively small amount given was effective resulting in 9 out 12 animals (75%) surviving the 72 hour post-resuscitation interval.

**Erythropoietin (EPO):** In keeping with the original objective of our grant but incorporating knowledge gained from the previous series, in which EPO had no effect on resuscitation and 72-hour survival but attenuated aortic lactate increases and organ dysfunction under conditions of severe but survivable hemorrhagic shock, we randomized in the subset of animals receiving VP to also receive EPO or vehicle control given – like in the preceding series – as a single intraosseous bolus dose of 1,200 U/kg after 10% of the blood volume had been removed (6 minutes from the start of BW).

**Hemorrhagic shock severity:** The effect of increasing the hemorrhagic shock severity was investigated only in the subset of animals receiving vasopressin by randomizing the animals to a severity of BW 65% or BW 75%.

Figure 2 summarizes the various groups and subsets investigated.

**Survival Effect**

Separate Kaplan-Maier survival analyses using the log-rank test were performed for each of the main factors while maintaining a balanced distribution of the remaining factors. As shown in Figure 3A, vasopressin was associated with statistically significant higher survival (68.8% vs 12.5%, \( p = 0.014 \)). The favorable effect occurred even though half of the animals in the vasopressin group, but none in controls, were subjected to more severe hemorrhagic shock BW (75% of blood volume). Administration of NS was also associated...
with higher 72-hour survival (25% vs 75%, \( p = 0.014 \)) as shown in Figure 3B. The use of EPO (Figure 3C) was associated with lower survival; however, the difference was not statistically significant. The increase in hemorrhagic shock severity had only a minimal and statistically insignificant effect on survival (Figure 3D).

Analysis of the combined effects of VP and NS on 72 hour survival is shown in Figure 4 demonstrating the highest survival rate associated with the combination of VP and NS and the worse with the absence of VP and NS.

A multiple linear regression analysis assessing the combined effects of vasopressin (yes[1]/No[0]), NS (Yes[1]/No[0]), erythropoietin (Yes[1]/No[0]), and hemorrhagic shock severity (65%[0]/75%[0]) on duration of survival (hours) demonstrated a statistically significant \( (p < 0.001) \) predictive effect of these independent variables with an \( R^2 = 0.632 \):

\[
SURVIVAL \text{ (HOURS)} = -5.7 + (55.9 \times \text{VASOPRESSIN}) + (35.0 \times \text{NS}) - (26.1 \times \text{ERYTHROPOIETIN}) - (9.0 \times \text{SEVERITY})
\]

However, only vasopressin \( (p < 0.001) \), NS \( (p = 0.002) \), and erythropoietin \( (p = 0.040) \), but not severity \( (p = 0.455) \) contributed statistically to the model.

### Hemodynamic and Metabolic Effects

The factorial design of the study allowed separate analyses of the effects of NS and the effects of NS on hemodynamic and metabolic variables as shown in Figures 5 through Figure 8. VP as expected increased systemic vascular resistance through the interval of blood withdrawal and that this effect was associated with a reduction in cardiac index and also a reduction in heart rate (Figure 5). These hemodynamic effects were associated with a lower end-tidal PCO\(_2\) (\( P_{ETCO_2} \)) and more intense lactic acidosis attributed to supply-dependent reduction in oxygen consumption (Figure 6). The effect, however, did not compromise survival. We interpreted these effects as indicative of a survival benefit prompted by redistribution of blood flow toward the heart by VP with likely reduction in oxygen requirements associated with a lower heart rate know to be an effect of VP modulating the baroreflex response. Low-volume fluid resuscitation was associated with an increase in left ventricular stroke work index and cardiac index – likely an effect on preload – that helped increase the aortic pressure and reduce the systemic vascular resistance (Figure 7). Metabolically, low-volume fluid resuscitation helped reduce lactic acidosis (Figure 8).

**Figure 4**: Kaplan-Maier survival curves comparing effects of vasopressin with normal saline (VP-NS), VP without NS (VP-noVP), no VP with NS (noVP-NS), and neither VP nor NS (noVP-noNS). The overall statistical significance was assessed by the log-rank test with all pairwise comparisons assessed by the Holm-Sidak’s test demonstrating significantly lower survival for VP-noNS (*\( p = 0.035 \)), noVP-NS (†\( p = 0.0198 \)), and noVP-noNS (‡\( p = 0.001 \)) compared with VP-NS. EPO, erythropoietin; BW, blood withdrawn; BR, blood reinfusion.
Figure 5: Effects of VP (open circles, n = 16) compared with vehicle control (closed circles, n = 8) on hemodynamic and myocardial function. Numbers in brackets indicate when the number of animals decreased from the preceding time point consequent to death. EPO, erythropoietin; VP, vasopressin; BW, blood withdrawal; HS, hemorrhagic shock; NS, normal saline; BR, blood reinfusion. The inset depicts the time course of the blood withdrawal (ml/kg) ending at 60 minutes in the 65% BW subset and at 80 minutes in the 75% BW group. Ao, aortic pressure; HR, heart rate; CI, cardiac index; SVRI, systemic vascular resistance index; LVSWI, left ventricular stroke work index; RVWI, right ventricular stroke work index. Values are shown as mean ± SEM. Differences between groups were analyzed by two-way repeated measures ANOVA. There was an overall statistically significant treatment effect for Ao mean, \((p = 0.016)\); heart rate, \((p < 0.001)\); CI, \((p < 0.001)\); SVRI \((p < 0.001)\) and RVWI \((p < 0.001)\). There was not statistically significant interaction between treatment and time. \(*p \leq 0.05\), denote statistically significant differences between groups at the specified time points using the Holm-Sidak test for multiple comparisons.
Figure 6: Effects of VP (open circles, n = 16) compared with vehicle control (closed circles, n = 8) on $P_{ET}$CO$_2$, lactic acidosis, and systemic oxygen metabolism. Numbers in brackets indicate when the number of animals decreased from the preceding time point consequent to death. EPO, erythropoietin; VP, vasopressin; BW, blood withdrawal; HS, hemorrhagic shock; NS, normal saline; BR, blood reinfusion. The inset depicts the time course of the blood withdrawal (ml/kg) ending at 60 minutes in the 65% BW subset and at 80 minutes in the 75% BW group. $P_{ET}$CO$_2$, end-tidal carbon dioxide; Ao, aortic; BE, base excess; DO$_2$, oxygen delivery index; VO$_2$, oxygen consumption index; VO$_2$/DO$_2$, oxygen consumption and delivery ratio.

Values are shown as mean ± SEM. Differences between groups were analyzed by two-way repeated measures ANOVA. There was an overall statistically significant treatment effect for $P_{ET}$CO$_2$, ($p < 0.001$); Ao lactate, ($p = 0.003$); Ao BE, ($p < 0.001$) and VO$_2$ ($p = 0.017$). There was an overall statistically significant interaction between treatment and time for Ao BE ($p = 0.040$). *$p \leq 0.05$, denote statistically significant differences between groups at the specified time points using the Holm-Sidak test for multiple comparisons.
Figure 7: Effects of NS (open circles, n = 12) compared with vehicle control (closed circles, n = 12) on hemodynamic and myocardial function. Numbers in brackets indicate when the number of animals decreased from the preceding time point consequent to death. EPO, erythropoietin; BW, blood withdrawal; HS, hemorrhagic shock; NS, normal saline; BR, blood reinfusion. The inset depicts the time course of the blood withdrawal (ml/kg) ending at 60 minutes in the 65% BW subset and at 80 minutes in the 75% BW group. Ao, aortic pressure; HR, heart rate; CI, cardiac index; SVRI, systemic vascular resistance index; LVSWI, left ventricular stroke work index; RVWI, right ventricular stroke work index. Values are shown as mean ± SEM. Differences between groups were analyzed by two-way repeated measures ANOVA. There was an overall statistically significant treatment effect for heart rate, \( p < 0.001 \); SVRI \( p = 0.007 \) and RVWI \( p = 0.045 \). There was an overall statistically significant interaction between treatment and time for CI \( p < 0.001 \), LVSWI \( p = 0.007 \) and RVWI \( p = 0.009 \). *\( p \leq 0.05 \), denote statistically significant differences between groups at the specified time points using the Holm-Sidak test for multiple comparisons.
Accordingly, the present series of experiments supports continuous intraosseous infusion of VP along with low-volume fluid resuscitation using NS for early and sustained hemodynamic stabilization during severe hemorrhagic shock in the battlefield pending evacuation to a medical treatment facility. VP infusion was associated with increases in systemic vascular resistance, reductions in cardiac index, and accentuation of lactic acidosis but reduced the risk of cardiac arrest suggesting a redistribution of blood flow from non-immediately vital territories towards vital organs. NS was associated with preload augmentation resulting in increases in cardiac index and reductions in lactic acid with the combination of VP and NS yielding 100% survival at 72 hours without organ dysfunction. The addition of EPO had no beneficial effect on initial resuscitation and survival contrary to the initial hypothesis. In fact, the data suggested a possible negative effect of EPO on initial resuscitability. The levels of severity; increasing the blood volume removed from 65% to 75%, had minimal detrimental effect on survival that was statistically insignificant suggesting that survival with the combination of VP and NS is feasible despite acute loss of 75% of the blood volume.

Figure 8: Effects of NS (open circles, n = 12) compared with vehicle control (closed circles, n = 12) on \(P_{ETCO2}\), lactic acidosis, and systemic oxygen metabolism. Numbers in brackets indicate when the number of animals decreased from the preceding time point consequent to death. EPO, erythropoietin; BW, blood withdrawal; HS, hemorrhagic shock; NS, normal saline; BR, blood reinfusion. The inset depicts the time course of the blood withdrawal (ml/kg) ending at 60 minutes in the 65% BW subset and at 80 minutes in the 75% BW group. \(P_{ETCO2}\), end-tidal carbon dioxide; Ao, aortic; BE, base excess; \(DO2\), oxygen delivery index; \(VO2\), oxygen consumption index; \(VO2/DO2\), oxygen consumption and delivery ratio. Values are shown as mean ± SEM. Differences between groups were analyzed by two-way repeated measures ANOVA. There was an overall statistically significant treatment effect for \(DO2\) \((p = 0.023)\) and \(VO2\) \((p = 0.003)\). There was not statistically significant interaction between treatment and time. \(*p \leq 0.05\), denote statistically significant differences between groups at the specified time points using the Holm-Sidak test for multiple comparisons.
We are currently examining the effects of VP and NS as described above in a model of uncontrolled bleeding caused by liver laceration to more closely mimic clinical scenarios in which bleeding in the battlefield is initially uncontrolled and accompanied by tissue injury.

**KEY RESEARCH ACCOMPLISHMENTS**

- The swine model developed by us with funding under award # W81XWH-11-2-0019 was highly effective in reproducing key features of severe hemorrhagic shock allowing assessment of the proposed interventions on initial resuscitation and subsequent survival while exploring the underlying mechanisms.
- Additional software development allowed modeling the blood volume removal pattern to more closely reflect spontaneous bleeding. Such capability can be used in future protocols to model any pattern of blood loss the investigators might want to examine.
- The findings strongly support the use of VP infusion started early after recognition of severe bleeding following by administration of NS in small bolus amounts for hemodynamic stabilization until definitive care is available.

**REPORTABLE OUTCOMES**

**PRESENTATIONS**


**ABSTRACTS**


**MANUSCRIPTS**

Effects of intraosseous erythropoietin during hemorrhagic shock in swine. Borovnik-Lesjak V; Whitehouse K; Baetiong A; Miao Y; Currie B; Velmurugan S; Radhakrishnan J; Gazmuri RJ (ready for submission).

**APPLICATIONS**

Pre-Proposal submitted in response to USAMRMC BAA 13-1 entitled “Hemorrhagic Shock Control by Blood Flow Redistribution and Hemostatic Enhancement.”

**CONCLUSION**

Intraosseous infusion of vasopressin from the onset of hemorrhagic shock until the start of blood reinfusion in combination with normal saline (half the amount of blood withdrawn) given at the end of hemorrhage over 30 minutes was highly effective in securing initial resuscitation and 72-hour survival under conditions of severe hemorrhagic shock, when compared with each intervention alone. Erythropoietin did not contribute to resuscitation and 72-hour survival and it might have had an adverse effect. Intraosseous infusion of vasopressin (delivered using a preloaded syringe and a small pump) and low-volume fluid resuscitation are low-skill techniques that could be deployed in far-forward battlefield operations providing extended hemodynamic stability in wounded soldiers pending evacuation to a medical treatment facility.
REFERENCES


APPENDICES

Curriculum vitae

SUPPORTING DATA

Included in the Body.
CURRICULUM VITAE

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November 20, 2013

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Present Title
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EDUCATION


1989-1991 Critical Care Medicine training. Department of Medicine, University of Health Sciences/The Chicago Medical School, North Chicago, IL.

1986-1989 Research Fellowship. Department of Medicine, University of Health Sciences/The Chicago Medical School, North Chicago, IL. Laboratory of Max Harry Weil, MD, PhD, Professor and Chairman, Department of Medicine.


1974-1980 MD degree. University of Chile School of Medicine.

1962-1973 Primary and High School, Saint Gaspar College, Santiago, Chile.

APPOINTMENTS

Present

2009-present Director, Resuscitation Institute at Rosalind Franklin University.

2002-present Professor (tenure-track). Department of Medicine and Chief, Division of Critical Care Medicine with cross-appointment in the Division of Pulmonary Medicine, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.

2009-present Professor. Department of Physiology and Biophysics, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.

2000-present Chief, Section of Critical Care Medicine
North Chicago VA Medical Center, North Chicago, IL.

1998-present ICU Director
North Chicago VA Medical Center, North Chicago, IL.

Past

2002-2009 Associate Professor. Department of Physiology and Biophysics, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.

2002-2006 Site Director (North Chicago VA Medical Center), Critical Care Fellowship Program, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.

1998-2002 Associate Professor. Department of Medicine, Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.

1998-2002 Assistant Professor. Department of Physiology and Biophysics, Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.

1995-1998 Assistant Professor. Department of Medicine, Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.
1992-1993  Associate Program Director of Critical Care Medicine. University of Health Sciences/The Chicago Medical School. North Chicago, IL.*
1992-1993  Chief, Critical Care Section. Medical Service, North Chicago VA Medical Center, North Chicago, IL.*
1991-1993  Vice-President for Research. Institute of Critical Care Medicine, a Public Educational and Research Foundation. North Chicago, IL, and Palm Springs, CA.*
1991-1992  Attending Physician in Critical Care Medicine, North Chicago VA Medical Center, North Chicago, IL.
1988-1989  Senior Research Fellow and Laboratory Supervisor. Dr. Max Harry Weil’s Research Laboratory. University of Health Sciences/The Chicago Medical School.
1984-1986  Staff physician. Center for the Critically Ill, Clínica Las Condes, Santiago, Chile.
1984-1986  Staff physician. Intensive Care Unit, DIPRECA Hospital, Santiago, Chile.

COMMITTEE ACTIVITIES (INTRAMURAL)

2004  Member, Search Committee, Chair Department of Physiology. Rosalind Franklin University of Medicine and Science.
2001-2006  Member, MD/PhD Combined Degree Admissions Committee. Rosalind Franklin University of Medicine and Science/The Chicago Medical School.
2000-present  Member, Department of Medicine Medical Executive Committee. Rosalind Franklin University of Medicine and Science/The Chicago Medical School.
2001-2003  Member, IACUC. Combined Hines and North Chicago VA committee.
2000-2001  Chair, Research Audit Committee. North Chicago VA Medical Center.
2000-2003  Chair, Department of Medicine Research Committee. Finch University of Health Sciences/The Chicago Medical School.
1998-present  Chair, Critical Care Committee at Captain James A. Lovell Federal Health Care Center.
1998-2011  Chair, CPR Committee at Captain James A. Lovell Federal Health Care Center.
1998-2000  Member of Infectious Control, Transfusion and Blood and Blood Products, and Surgical Case Review Committees. North Chicago VA Medical Center.
1997-1999  Co-Chair, Department of Medicine Research Committee. Finch University of Health Sciences/The Chicago Medical School.

*Appointments relinquished in 1993 to complete PhD program.
1997-1998 Chair, Animal Care Committee. Member of Critical Care and CPR, Infectious Control, Transfusion and Blood and Blood Products, Surgical Case Review, and Research and Development Committees. North Chicago VA Medical Center.

1988-1991 Member, Department of Medicine Research Committee. Finch University of Health Sciences/The Chicago Medical School.

1992-1993 Chairman, Critical Care and CPR Committee. Member, Infectious Disease, Blood Products and Transfusion, Surgical Case Review, and Ethical Advisory Committees. North Chicago VA Medical Center, North Chicago, IL.*

COMMITTEE ACTIVITIES (EXTRAMURAL)

2009-2013 Member, Clinical and Integrative Cardiovascular Science (CICS) Study Section, Center for Scientific Review.

2011-2013 Member, American Heart Association’s Advanced Cardiac Life Support (ACLS) Subcommittee.

2006-2011 Member, American Heart Association’s Basic Life Support (BLS) Subcommittee (appointed from July 1, 2006 to June 30, 2008; reappointed until June 30, 2011).

2008 Member (temporary), Clinical and Integrative Cardiovascular Science (CICS) NIH Study Section. February 7-8, Washington, DC.

2007 Member (temporary), Myocardial Ischemia and Metabolism (MIM) NIH Study Section. February 22-23, Washington, DC.

2006 Member (temporary), Clinical and Integrative Cardiovascular Science (CICS) NIH Study Section. November 2-3, Washington, DC.

2000-2003 Member, Research Committee, Society of Critical Care Medicine.

MISCELLANEOUS ACTIVITIES


2009-present Director, Resuscitation Institute at Rosalind Franklin University.


1998-Present Software development (for research applications) using LabVIEW, National Instruments.

SPECIALTY AND SUBSPECIALTY CERTIFICATION

1993 Critical Care Medicine Board (recertified in 2013).

1992 American Board of Internal Medicine (recertified in 2002 and 2012).

1984 Chilean National Examination in Internal Medicine.

LICENSURE

1989 Illinois License, No. 036-078444
1980 Doctor of Medicine and Surgery, Chile

PROFESSIONAL SOCIETY MEMBERSHIP
2005-present Honorary Member “Sociedad Decano Lorenzo Sazié.” Santiago, Chile  
1997-present American Heart Association  
1997-present Fellow of the American College of Critical Care Medicine  
1990-present Society of Critical Care Medicine, U.S.A.  
1990-present American Federation for Medical Research.  
1988-1996 American Association for the Advancement of Science.  
1986-present Medical Society of Santiago, Chile.  
1983-present Chilean Medical College.

EDITORIAL AND PEER-REVIEW ACTIVITIES

Periodicals
1993-present Reviewer for *Critical Care Medicine; Circulation; American Journal of Physiology; and Journal of Applied Physiology*
1996-present Ad-hoc reviewer for *Annals of Emergency Medicine; The Lancet; Critical Care; The Journal of the American College of Cardiology; Expert Opinion on Therapeutic Patents; Resuscitation; and Journal of the American Association for Laboratory Animal Science; BMC Veterinary Research.*

Other
2009-present Associated Editor, Acta Medico-Biotechnica, University of Maribor, Slovenia.
2007-present Member, Scientific Committee, International Seminar on Acute Conditions, University of Maribor, Maribor, Slovenia.
2006-2009 Member, Faculty of 1000 Medicine, Acute Cardiovascular Problems, Critical Care & Emergency Medicine.
2003-2012 Abstract reviewer for the AHA Scientific Sessions.
1993-present Occasional reviewer of grant proposals for: FONDECYT (Chilean National Foundation for Science and Technology); Ministry of Education, Science and Sport, Republic of Slovenia, and the Austrian Science Fund (FWF).
1991-present Abstract reviewer for the Society of Critical Care Medicine Educational and Scientific Annual Symposia.

PROFESSIONAL INVITATIONS

Invited Lectures
1985 [Nutrition in the Patient with Acute Renal Failure]. First Course of Renal Failure in the Critically Ill. Center for the Critically Ill, Clinica Las Condes, Santiago, Chile.

1985 (a) [Hemodynamic Monitoring], (b) [Nutrition in the Critically Ill], (c) [Airway Management, and Venous Catheterization]. Hospital del Salvador, Santiago, Chile.

1986 [Renal Failure in the Critically Ill] (panel). Center for the Critically Ill, Clinica Las Condes, Santiago, Chile.


1986 (a) [Hemodynamic Monitoring in Acute Myocardial Infarction], (b) [Problems and Complications in Hemodynamic Monitoring (workshop leader)]. Second Course on Hemodynamic Monitoring. Center for the Critically Ill. Clinica Las Condes, Santiago, Chile.

1986 [Pathophysiology, Diagnosis and Treatment of Shock]. Mutual de Seguridad. Santiago, Chile.

1986 (a) [Clinical Clues in the Diagnosis and Treatment of Shock], (b) [Hemodynamic Monitoring: The Nurse’s Role]. Hospital DIPRECA, Santiago, Chile.


1986 [Clinical Application of Electrocardiography] (panel moderator). Chilean Society of Cardiology, Santiago, Chile.

1988 [Cardiac Resuscitation by Extracorporeal Pump Oxygenator (ECPO) after Failure of Precordial Compression]. Chicago Cardiology Group, Chicago, IL, U.S.A.


1989 [The Rational Management of Cardiac Arrest. Departments of Anesthesia and Cardiology]. Catholic University of Chile. December 27 and 29. Santiago, Chile.


1990 (a) [Acute Respiratory Distress Syndrome (panel)], (b) [The Rational Management of Cardiac Arrest], (c) [Cardiac Resuscitation by Extracorporeal Circulation]. Eighth Annual Symposium, Chilean Society of Intensive Care Medicine, November 17-20. Santiago, Chile.

1990 [The Rational Management of Cardiac Arrest]. (a) Higuerras Hospital, Talcahuano and (b) Sanatorio Alemán, Concepción, November 25; and (c) National Institute of Respiratory Diseases, November 26. Santiago, Chile.

1991 New Directions for Basic and Advanced Life Support. (a) Medical Grand Rounds, University of Health Sciences/The Chicago Medical School, July 31, North Chicago, IL;
(b) The Tenth Annual Chicago Critical Care Symposium and Review Course, October 10-13. Chicago, IL; and (c) Cook County Hospital, Critical Care Conference, October 21. Chicago, IL, U.S.A.

1992 (a) Buffer Agents for the Treatment of Acidosis [panel], (b) Options for Cardiac Resuscitation When Conventional Methods Fail. 30th Annual University of Southern California Annual Symposium on Critical Care Medicine. February 3-7. Las Vegas, Nevada, U.S.A.


1994 (a) [Is Positive Pressure Ventilation Essential During Early CPR?], (b) [Monitoring the Resuscitation Effort], (c) [Advances in Cardiopulmonary Resuscitation]. LXVII Chilean and International Congress of Surgery. November 28 - December 1. Santiago, Chile.


1997 (a) [The Pathophysiological Bases of Cardiopulmonary Resuscitation]; (b) [Clinical Effectiveness of New Resuscitation Techniques]; (c) [Hemodynamic Guidance During Cardiac Resuscitation]; (d) [Myocardial Protection During Cardiac Arrest]; (e) [Chain of Survival: Community Involvement and Access to Emergency Services]; (f) [Ethical and Legal Aspects of Cardiopulmonary Resuscitation] (panel). First Symposium on


1998 Resuscitation of the Arrested Heart: Research Activities at North Chicago. Department of Medicine Annual Retreat. Finch University of Health Sciences/Chicago Medical School.


2000 Myocardial Protection by Inhibition of Sarcolemmal Sodium Influx. Naval Dental Research Institute/United States Army Dental Research Detachment/North Chicago VA Medical Center Scientific Colloquium. May 5. Great Lakes Navy Hospital, Great Lakes, IL.

2000 Successful Ventricular Defibrillation by Inhibition of the Sodium-Hydrogen Exchanger Isoform-1. Fifth Annual Meeting of Midwest Physiological Society. June 5-6. Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.

2000 NHE-1 Inhibition: A New Treatment Approach for Cardiac Resuscitation. Medical Grand Rounds, June 7, Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.


2001 Beneficial Effects of NHE-1 Inhibition in a Rat Model of Cardiac Arrest. The XVII World Congress of the International Society for Heart Research, July 10th, Winnipeg, Manitoba, Canada.

2001 Improving Resuscitation from Cardiac Arrest by Inhibition of the Sodium Hydrogen Exchanger Isoform 1. Aventis Pharma, August 16th, Frankfurt, Germany.

2001 Myocardial Protection during Ventricular Fibrillation by Inhibition of the Sodium-Hydrogen Exchanger Isoform-1. Pulmonary and Critical Care Medicine Grand Rounds, August 24th, University Hospitals of Cleveland and Case Western Reserve University, Cleveland, OH.

Medicine, University of Southern California and The Institute of Critical Care Medicine, February 18 – 22, Cæsars Palace Hotel, Las Vegas, Nevada.

2002 NHE-1 Inhibition: A Potential New Treatment for Resuscitation from Cardiac Arrest. Medical Grand Rounds, April 4, Finch University of Health Sciences/The Chicago Medical School, North Chicago, IL.

2002 Optimal Timing for Electrical Defibrillation. Resuscitation and Bioengineering Science. Emergency Resuscitation Center. The University of Chicago and Argonne National Laboratory, April 18-19, Argonne National Laboratory, Argonne, IL

2002 NHE-1 Inhibition: A New form of Treatment for Resuscitation from Ventricular Fibrillation. Center for Magnetic Resonance Research, May 8, Evanston, IL


2004 Experimental and Clinical Advances in Cardiopulmonary Resuscitation. Department of Medicine Grand Rounds, May 20, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL

2004 Minimizing Myocardial Ischemia and Maximizing Myocardial Protection during Resuscitation from Cardiac Arrest (lecture, June 25); Focus on Myocardial Preservation, Reperfusion Injury, Post-Resuscitation Myocardial Dysfunction, and the Role of Buffer Agents during Cardiac Arrest (panelist, June 25); From Basic to Advanced Life Support (panelist, June 26); Revisiting the Guidelines (panel co-chairman, June 26); Promising Pharmacological Agents for CPR (lecture, June 26); and Technological Innovations to Coordinate and Prioritize Electrical and Mechanical Interventions (panelist, June 26). First Safar-Weil Conference on Cardiopulmonary and Cerebral Resuscitation. June 25-27, Venezia, Italy.


2004 NHE-1 Inhibition for Resuscitation from Sudden Cardiac Death. Department of Anesthesia, Leopold Franzens University of Innsbruck. June 29, Innsbruck, Austria.

2004 NHE-1 Inhibition and Coronary Blood Flow during VF are both Determinants of Post-Resuscitation Myocardial Function. Resuscitation Science Symposium (ReSS), grantees
meeting, co-sponsored by the National Heart, Lung, and Blood Institute and the American Heart Association. November 5-6, New Orleans, LA.

2004 Myocardial Preservation, Reperfusion Injury, and Post-Resuscitation Myocardial Dysfunction (lecture, November 13th); Cardiac Arrest (session chair and panelist, November 13th). International Symposium on Critical Care Medicine, 19th Annual Meeting (APICE). November 12-15, Trieste, Italy.


2005 Myocardial Protection during Cardiac Resuscitation by Limiting Sarcolemmal Sodium Entry. National Heart, Lung, and Blood Institute, March 18, Bethesda, MD.

2005 Sudden Cardiac Arrest and Mitochondrial Injury: A New Therapeutic Target? Research Symposium, North Chicago VA Medical Center, March 25, North Chicago, IL.


2005 Pathophysiology and Management of Myocardial Injury during Cardiopulmonary Resuscitation. 2nd Seminar with International Attendance. Emergency Conditions: Signs, Symptoms, Syndromes, Differential Diagnosis and Management, October 7, Congress Center Habakuk, Maribor, Slovenia.

2005 Myocardial Protection by NHE-1 Inhibition. Resuscitation Science RFAs Grantees’ Meeting, October 21, Two Rockledge Centre, Bethesda, Maryland.


2006 2005 Guidelines for CPR and Emergency Cardiac Care: Renewed Emphasis on Blood Flow (lecture, May 11); Technological Advances in Resuscitation: A way to Implement Guidelines and Beyond (lecture, May 11); A Practical Approach to Fluid and Electrolyte Management (lecture, May 13). [International Course on Medical Emergencies and
Critical Ill Patient, organized by a 16-hospital Chilean ICU network]. Hotel Crowne Plaza, May 11-13, Santiago, Chile.

2006  Resuscitation 2006. Clínica Las Condes, May 18, Santiago, Chile.
2006  Moderator for Panel Discussion. Advances in Post-Resuscitation Care. Organized by the Emergency Resuscitation Center, the University of Chicago and Argonne National Laboratory. The Gleacher Center, June 10, Chicago, IL.
2006  Advances in Cardiopulmonary Resuscitation: From Bench to Bedside. Department of Medicine Grand Rounds, July 5, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.
2006  Novel Targets for Ameliorating Injury Caused by Ischemia and Reperfusion. Department of Medicine Research Symposium. August 23, Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL.
2006  Basic CPR Physiology and New Research Directions. October 6, UT Southwestern Medical Center. Children's Medical Center, Dallas, TX.
2006  Cardiopulmonary resuscitation: Bridging the Gap between Knowledge and Practice. October 17, Lake County Medical Society, Lincolnshire, IL.
2007  Targets for Myocardial Protection during Resuscitation from Cardiac Arrest. Medical Service, Denver VA. February 9, Denver, CO.
2007  Management of Life Threatening Electrolyte Disorders. March 7th. Recognition and Management of Intrathoracic Crises with Special Reference to Cardiac Tamponade. March 9th. 45th Annual Symposium on Critical Care, Trauma and Emergency Medicine. Keck School of Medicine, University of Southern California, and The Weil Institute of Critical Care Medicine, March 5 – 9, Ceasars Palace Hotel, Las Vegas, Nevada.
2007  In-Hospital Resuscitation (forum). Clínica Dávila, August 6, Santiago, Chile.
2007  Myocardial Effects of Cardiac Arrest and Resuscitation with Especial Reference to Mitochondrial Injury (lecture). University of Maribor, Faculty of Medicine, October 3, Maribor, Slovenia.
2007  Myocardial Effects of Cardiac Arrest and Resuscitation with Especial Reference to Mitochondrial Injury (lecture, October 5); Critical Care Knowledge in Emergency Medicine. Emergency Conditions: Signs, Symptoms, Syndromes, Differential Diagnosis and Management, October 4-6, Congress Center Habakuk, Maribor, Slovenia.
2008  Sodium-Hydrogen Exchange Inhibition during Resuscitation: Saving Myocardium by Protecting Mitochondria? (lecture, hospital, April 23). Perspectives on How to Improve

2008 Conference: Myocardial protection after CPR; Practical Lessons Learned on How to Setup a Research Laboratory (May 8); A Practical Approach to Fluid Management (May 9); Cardiopulmonary Resuscitation: Bridging the GAP Between Knowledge and Practice (May 10). Physio-Control. XIII Brazilian Congress of Intensive Care Medicine and 1st International Symposium of the World Federation of Intensive and Critical Care Medicine. Salvador City, Bahia, Brazil, May 6 – 10.


2008 Targeting Mitochondria for Resuscitation from Cardiac Arrest. Department of Medicine Grand Rounds, Rosalind Franklin University of Medicine and Science/The Chicago Medical School. North Chicago, IL, September 17.


2009 Enhancing the Hemodynamic Efficacy of Chest Compression by Preserving Mitochondrial Bioenergetic Function. Cardiovascular Research Center’s Visiting Faculty Seminar Series, Mount Sinai School of Medicine, New York, NY, January 16.


2009 Improving CPR Hemodynamics and Outcomes by Preserving Left Ventricular Distensibility. Department of Medicine Grand Rounds. Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL, August 19.

2009 Key Points for Improving the Outcome of Out-of-Hospital Cardiac Arrest (lecture, August 31), Inotropic Options for Post-Resuscitation Myocardial Dysfunction (lecture, August 31), CPR: From Flying Blind to Flying Right (lecture, September 1), Cardiopulmonary Resuscitation (moderator, August 31). 10th Congress of the World
Raúl J. Gazmuri, MD, PhD, FCCM

Federation of Societies of Intensive and Critical Care Medicine (WFICCM), Fortezza de Baso, Florence, Italy, August 28 – September 1.


2009 Medical Emergency Response System (MERS) at the North Chicago VAMC (Grand Rounds). Advances in Medicine, Surgery, and Psychiatry, Department of Veterans Affairs North Chicago and Rosalind Franklin University of Medicine and Science. North Chicago, IL, November 3.

2010 Advances in Resuscitation. Department of Medicine Grand Rounds. Rosalind Franklin University of Medicine and Science/The Chicago Medical School, North Chicago, IL, February 10.

2010 Resuscitative Medicine: Improving CPR Hemodynamics and Outcomes by Preserving Left Ventricular Distensibility. The Heart Institute for Children Research Club. Hope Children’s Hospital, Oak Lawn, IL, March 5.

2010 Key Factors for Improving Outcome after Sudden Cardiac Arrest (lecture, March 19); Improving CPR Hemodynamics by Maintaining Left Ventricular Distensibility (lecture, March 19); An Elective in Critical Care Medicine for Second-Year Students (panel New Directions in Health Professions Education, March 19). 65th Annual Medwest Clinical Conference & Technology Summit. Westing Lombard Yorktown Center, Lombard, IL, March 18-19.


2010 Pathophysiology and Severity of Post-Resuscitation Myocardial Dysfunction (lecture); ACLS Recall on Skills and Pharmacological Agents (panel); chairman for three sessions on CPR topics. APICE 23rd International Symposium on Critical Care Medicine, Catania, Italy, November 5-7.


2011 Minimal Hemodynamic effects of Increasing Respiratory Rate and Volume during CPR but large Impact on P\textsubscript{ET}CO\textsubscript{2} (lecture, June 11). Optimizing the Efficacy of Circulatory Support during CPR (panel, June 11). Optimizing Transitions from Laboratory to Clinic (panel, June 11). The Wolf Creek XI Conference. Westin Mission Hills Resort & Spa, Rancho Mirage, CA, June 9-12.

2011 Prevention of in Hospital Cardiac Arrest by Early Recognition and Treatment of Physiological Deterioration. Department of Medicine Grand Rounds. Rosalind Franklin
University of Medicine and Science/The Chicago Medical School, North Chicago, IL, September 14.

2011 Cardiac arrest – From the Lab to Clinical Trials (lecture, December 11); A Giant of Critical Care – Prof. Max Harry Weil (panel, December 11). APICE Masterclass. Annual International Meeting Mediterranean School of Intensive and Critical Care Medicine. Catania University, Catania, Italy, December 9 – 11.


2012 Targeting Mitochondria during CPR (lecture, September 9); State-of-the-Art in Critical Care (panel, September 8); Quality of CPR (panel, September 8); Post-Resuscitation Care (panel, September 9). Weil Conference on Cardiac Arrest, Shock and Trauma. Istituto Mario Negri, Milan, Italy, September 8–9.


2013 Venous Tone Augmentation with Vasopressin for Hemodynamic Stabilization during Hemorrhagic Shock (lecture, May 31); Estrogen Fails to Facilitate Resuscitation from VF in Male Rats (June 1). Optimizing Monitoring and Management of Circulatory Shock: Goal Directed Therapy (panel, May 31); After More than 50 Years of Modern CPR, do we Really Save More Lives? What are the Major Limiting Factors that Prevent Us to Do So? (panel, May 31); Optimizing the Efficacy of Circulatory Support during CPR: The role of Mechanical Devices (panel, June 1); Optimizing Transitions from Laboratory to Clinical Practice (panel, June 1); Optimizing Post-Resuscitation Management: Priorities of Post-Resuscitation Care. The Wolf Creek XII Conference. Westin Mission Hills Resort & Spa, Rancho Mirage, CA, May 30–June 2.


Other Invitations

2003 To serve as expert reviewer for the International Liaison Committee of Resuscitation’s (ILCOR) 2005 International Consensus on Emergence Cardiovascular Care (ECC) and Cardiopulmonary Resuscitation (CPR) Science with Treatment Recommendations Conference (C2005), reviewing the topic “Is CPR before defibrillation safe, effective, and feasible?”

2003 To serve as section editor for the June 2003 and June 2004 issues of Current Opinion in Critical Care dedicated to Cardiopulmonary Resuscitation.

2005 To serve as invited editor for the November 2005 issues of Clinic@s de Medicina Crítica dedicated to Cardiopulmonary Resuscitation.

2005 To co-moderate a session on oral presentations on resuscitation topics at the 2005 annual Scientific Sessions of the AHA.

2006 To join the APICE 2006 International Scientific Committee.

2007 To co-moderate a session on oral presentations on resuscitation topics at the 2007 annual Scientific Sessions of the AHA and to co-moderate a poster discussion at the 2007 Resuscitation Science Symposium.

2008 Worksheet presenter at ILCOR meeting (November 5); Co-moderator of a poster session at the Resuscitation Science Symposium (November 9); Co-moderator of an abstract presentation session at AHA Scientific Sessions (November 10).

2009 To serve as expert reviewer for the International Liaison Committee of Resuscitation’s (ILCOR) 2010 International Consensus on Emergence Cardiovascular Care (ECC) and Cardiopulmonary Resuscitation (CPR) Science with Treatment Recommendations Conference (C2010).

COURSES ORGANIZED

1985 [Second Course of Hemodynamic Monitoring (Coordinator)]. Center for the Critically Ill, Clinica Las Condes, Santiago, Chile.

1986 [Diagnosis of Emergencies in Intensive Medicine (Director)]. DIPRECA Hospital, Santiago, Chile.

2004 Sudden Cardiac Death: From Cell Physiology to Clinical Resuscitation. A symposium jointly sponsored by the Department of Medicine and the Department of Physiology and Biophysics and by the Medical Service at the North Chicago VA Medical Center. October 23. North Chicago, IL. Role: Program Director and Speaker. Invited speakers included several nationally recognized investigators.

2006 Symposium on Sudden Cardiac Arrest: From Research to Resuscitation, held at the Rosalind Franklin University of Medicine and Science, April 27-29. Program Director, Speaker, and Moderator. Invited speaker included 14 internationally recognized leaders in CPR.

2006 ICU Elective for 2nd year medical students (MMED 699 Critical Care Medicine). Fall quarter – 12 sessions, 2 hours each.

2010 First Maribor Resuscitation Summit: On The Future of CPR.” Maribor, Slovenia, September 9-11. Co-Organizer with Dr. Štefek Grmec. Invited speaker included 16 internationally recognized leaders in CPR.
HOST OF RECOGNIZED SCIENTISTS AT DEPARTMENTAL LEVEL

2005 Morris Karmazyn, PhD, Canada Research Chair in Experimental Cardiology; Director, Heart and Stroke Foundation of Ontario; Professor of Physiology and Pharmacology, University of Western Ontario, Canada. *Mediation of Ischemic Myocardial Injury, Hypertrophy and Heart Failure by Sodium-Hydrogen Exchange*. Rosalind Franklin University of Medicine and Science, May 26.

2008 Roger J. Hajjar, MD, Professor of Medicine and Director of the Cardiovascular Research Center at Mount Sinai Medical Center, New York, NY. *Targeting Calcium Cycling in Heart Failure*. Department of Physiology & Biophysics seminar series. Rosalind Franklin University of Medicine and Science, March 27.

HOST OF THE RESUSCITATION INSTITUTE LECTURE SERIES

2012 Tom P. Aufderheide, MD, FACEP, FACC, FAHA; Professor of Emergency Medicine; Associate Chair of Research Affairs; Director, Adult Translational Research Unit; Department of Emergency Medicine; Medical College of Wisconsin. *Harnessing the Thoracic Pump to Treat Patients in Cardiac Arrest: From 1960 to the Present* (March 12).

2012 Terry L. Vanden Hoek, MD, FACEP; Professor and Chair Department of Emergency University of Illinois at Chicago. *Cardiopulmonary Resuscitation in 2012: New Opportunities for Translational Science* (June 8).

2012 Morris Karmazyn, PhD; Canada Research Chair in Experimental Cardiology; Professor, Department of Physiology and Pharmacology; University of Western Ontario, Canada. *The Myocardial Sodium-Hydrogen Exchanger and its Role in Heart Disease: From Basic Research to Clinical (Mis)Trials* (November 29).

2013 Wanchun Tang MD, MCCM, FCCP, FAHA Professor, President, and Chief Scientific Officer of the Weil Institute of Critical Care Medicine; Clinical Professor, Keck School of Medicine, University of Southern California; Professor of Emergency Medicine, UC San Diego School of Medicine. *Recent Advances in Cardiopulmonary Resuscitation* (August 21).

HONORS AND AWARDS (First or Senior Author)

1984 Acknowledgment to the best scientific project. Norgine Laboratory Prize. XXI Chilean Congress of Cardiology and Cardiovascular Surgery. December, Viña del Mar, Chile. [Arterial and venous prostaglandin E2 levels in patients with valvular disease]. Guarda E, Zamorano B, **Gazmuri RJ**, Escobar E.


1994 Honorary Member, Chilean Society of Surgeons. December 1. Santiago Chile.


Research Citation (one of 30 semi-finalists). Society of Critical Care Medicine 30th Educational and Scientific Symposium, February 13, San Francisco, CA. Cariporide Facilitates Successful Defibrillation and Improves Post-Resuscitation Hemodynamic Function after Prolonged Untreated VF. **Gazmuri RJ**, Ayoub IM, Kolarova J, Damera M.

Research Citation (one of 6 finalists). Society of Critical Care Medicine 31st Critical Care Congress, January 29, San Diego, CA. Successful Treatment of Prolonged Untreated Ventricular Fibrillation Requires Chest Compression before Electrical Shocks. Kolarova J, Yi Zhong, Ayoub IM, **Gazmuri RJ**.


Research Citation (one of 5 finalists). Society of Critical Care Medicine 32nd Critical Care Congress, February 1, San Antonio, TX. Inhibition of the sodium-hydrogen exchanger isoform-1 (NHE-1) ameliorates reperfusion arrhythmias and prevents episodes of recurrent VF. Ayoub IM, Kolarova J, Yi Z, Maldonado MA, **Gazmuri RJ**.

Research Citation. Society of Critical Care Medicine 34th Critical Care Congress, January 18, Phoenix, AZ. Zoniporide ameliorates post-resuscitation myocardial dysfunction by flow independent mechanisms. Ayoub IM, Kolarova JD, Radhakrishnan J, Wang S, **Gazmuri RJ**.

Research Citation. Society of Critical Care Medicine 34th Critical Care Congress, January 18, Phoenix, AZ. Zoniporide ameliorates intramyocardial lactate increases during resuscitation from ventricular fibrillation. Radhakrishnan J, Wang S, Ayoub IM, Kolarova JD, **Gazmuri RJ**.


Courand and Comroe Young Investigator Prize in Cardiopulmonary and Critical Care (one of 5 finalists), Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. American Heart Association Scientific Sessions 2009. November 17, Orlando, Florida. The mitochondrial permeability transition pore opens during
ventricular fibrillation in a rat model of closed chest resuscitation. Ayoub IM, Radhakrishnan J, Upadhyaya MP, Gazmuri RJ.

2010 Second Prize Poster Winner at the Annual Hines/North Chicago VA Research Day. April 29, Edward Hines, Jr VA Hospital, Hines, IL. Preservation of left ventricular myocardial distensibility using a novel sodium-hydrogen exchanger isoform-1 inhibitor markedly enhances the hemodynamic efficacy of chest compression. Ayoub IM, Upadhyaya MP, Radhakrishnan J, Gazmuri RJ.


BIBLIOGRAPHY

BOOK CHAPTERS


**PEER REVIEWED ORIGINAL SCIENTIFIC ARTICLES**


**Peer Reviewed Pharma-Sponsored Multicenter Clinical Trials**


**Consensus Statements and Guidelines**


**CASE REPORTS**


**REVIEW ARTICLES**


13. **Gazmuri RJ**. [Advances in cardiopulmonary resuscitation]. *Clinic@s de Medicina Crítica* 2004;2:1-23.


**CONFERENCE PROCEEDINGS**


**LETTERS TO THE EDITOR**


5. **Gazmuri RJ**. Response to the letter to the editor entitled “Cardiac arrest in the elderly: CPR or no CPR, that is the question!” *Chest* 1997;112:1147-1148.


EDITORIALS/COMMENTARIES


23. Gazmuri RJ. [Editorial to issue dedicated to cardiopulmonary resuscitation]. Clinic@s de Medicina Crítica 2005;3: (In Press)


ABSTRACTS


24. von Planta M, Weil MH, **Gazmuri RJ**, Bruno S, Rackow EC. Failure of calcium channel blockers (CCB) to increase resuscitability during CPR. *Chest* 1988;94:6S.


137. Radhakrishnan J, Upadhyaya MP, Ayoub IM, **Gazmuri RJ**. Erythropoietin administered during resuscitation from cardiac arrest improves cytochrome c oxidase activity in left ventricular tissue. *Circulation* 2010;122:A169.


140. Radhakrishnan J, Ayoub IM, Upadhyaya MP, **Gazmuri RJ**. Preservation of left ventricular myocardial distensibility by a novel NHE-1 inhibitor BIX with no effect on caspase-3 activity. *Crit Care Med* 2010;38(Suppl.):446.


**PHD THESIS**

Gazmuri RJ. Myocardial Function after Resuscitation From Cardiac Arrest. Finch University of Health Sciences/The Chicago Medical School. Department of Physiology and Biophysics, North Chicago, IL 1994.

**THESIS ADVISOR (PHYSICIAN ASSISTANT PROGRAM AT FINCH UNIVERSITY OF HEALTH SCIENCES)**


**PHD THESIS MENTOR (DEPARTMENT OF PHYSIOLOGY & BIOPHYSICS AT ROSALIND FRANKLIN UNIVERSITY OF MEDICINE AND SCIENCE)**


**PATENTS**

**FACILITATION OF RESUSCITATION FROM CARDIAC ARREST BY ERYTHROPOIETIN**


**CIRCULATING CYTOCHROME C AS BIOMARKER OF REPERFUSION INJURY AFTER WHOLE BODY ISCHEMIA AND PREDICTOR OF SURVIVAL**

Provisional application No. 60/937728 filed on June 29, 2007 (112461.00057)  Status, pending.

**RESEARCH GRANTS (PAST/ACTIVE)**

**PEER REVIEWED**

**Past**
1981-1983  “The Role of Prostaglandins in the Cardiac Adaptation to Overload.”
Source: Libraries and Research Department, University of Chile. #1156-8114.
Role: Research Assistant.
Principal Investigator: Edgardo Escobar, MD

1984-1985  Project: The Role of Prostaglandins in the Development of Cardiac Failure
Source: Libraries and Research Department, University of Chile. #M18761-8413.
Role: Research Associate.
Principal Investigator: Edgardo Escobar, MD

1987-1994  Project: Myocardial Acid-Base Changes During CPR
Source: National Institutes of Health, NHLBI #1R01 HL39148-01 and Competing Continuation #1R01 HL39148-04A2.
Annual Direct Costs: $82,000 to approximately $200,000.
Role: Co-Investigator.
Principal Investigator: Max Harry Weil, MD, PhD

Source: American Heart Association, #890912.
Annual Direct Costs: $29,900.
Role: Collaborating Investigator.
Principal Investigator: Max Harry Weil, MD, PhD

1989-1991  Project: Resuscitation after Prolonged Cardiac Arrest
Source: National Institutes of Health, NHLBI #1RO1 HL42590-01.
Role: Co-Investigator.
Principal Investigator: Max Harry Weil, MD, PhD

1998-2000  Project: Myocardial Protection During Cardiac Arrest
Source: VA Merit Review.
Annual Direct Cost: $105,800 to $109,100.
Role: Principal Investigator.

2001-2004  Project: Myocardial Protection During Ventricular Fibrillation
Source: VA Merit Review.
Annual Direct Cost: $150,000 to $225,500.
Role: Principal Investigator.

2002-2006  Project: Myocardial Protection by NHE-1 Inhibition
RFA: Basic Research to Improve Cardiopulmonary and Neurological Outcomes.
Source: NHLBI, 1 R01 HL71728-01.
Annual Direct Cost: $175,000 to $225,000.
Role: Principal Investigator.

RFA: SBIR/STTR - Technologies for monitoring and performing resuscitation.
Source: NIH.
Annual Direct Cost: $100,000.
Role: Collaborator.
2006-2007  Project: **Myocardial Protection by GSK-3β Inhibition during Resuscitation from Cardiac Arrest**  
Internal Funding Program (pilot grant).  
Source: Rosalind Franklin University of Medicine and Science.  
Annual Direct Cost: $25,000.  
Role: Principal Investigator.

2006-2007  Project: **Bridge Funds**  
Sponsor: Rosalind Franklin University of Medicine and Science  
Total Cost: $50,000  
Role: Principal Investigator.

**Active**

2010-2014  Project: **Myocardial Effects of Erythropoietin during Resuscitation from Cardiac Arrest**  
Source: VA Merit Review.  
Annual Direct Cost: $150,000  
Role: Principal Investigator.

2010-2013  Project: **Intraosseous Erythropoietin for Acute Tissue Protection in Battlefield Casualties Suffering Hypovolemic Shock**  
Source: Defense Medical Research and Development Program (DMRDP), Applied Research and Technology Development Award (ARADTA).  
Annual Direct Cost: $400,000  
Role: Principal Investigator.

2012-2013  Project: **Plasma Cytochrome c as Biomarker of Traumatic Injury and Predictor of Outcome**  
Source: Chicago Medical School and Advocate Lutheran General Hospital Translational Research Pilot Grant Program  
Annual Direct Cost (RFUMS): $70,250  
Role: Co-Principal Investigator.

**Non-Peer Reviewed (Investigator Initiated)**

1987-1988  Project: **Effects of an Extracorporeal Pump Oxygenator in Myocardial Resuscitability during Experimental Cardiac Arrest**  
Source: Baxter (American Bentley).  
Annual Direct Costs: $82,000.  
Principal Investigator: Max Harry Weil, MD, PhD  
Role: Co-Investigator.

1995-1997  Project: **Start-up funds**  
Source: Finch University of Health Sciences/The Chicago Medical School.  
Total Cost: $20,000.  
Role: Principal Investigator.

2000-2001  Project: **Bridge funds**  
Source: Finch University of Health Sciences/The Chicago Medical School.  
Total Cost: $20,000.  
Role: Principal Investigator.

2004-2005  Project: **Myocardial Protection during Ventricular Fibrillation by NHE-1 Inhibition Using Cariporide: Studies in a Porcine Model**  
Sponsor: Aventis Pharma, Frankfurt, Germany  
Total Cost: $40,000.  
Role: Principal Investigator.
2008-2009  Project: **Investigation of an NHE-1 Inhibitor for Resuscitation from Cardiac Arrest**  
Sponsor: Boehringer Ingelheim Pharmaceuticals, Inc.  
Total Cost: $50,000  
Role: Principal Investigator.

2009-2010  Project: **Volume-Controlled Manual Ventilation during Resuscitation from Cardiac Arrest**  
Sponsor: Dessinier Corporation  
Total Cost: $120,000  
Role: Principal Investigator.

2009-2010  Project: **Vitamin-C Preserves Myocardial Distensibility during Resuscitation from Cardiac Arrest**  
Sponsor: Zdravstveni Dom. Dr. Adolfa Drolca, Maribor, Slovenia  
Total Cost: $20,000  
Role: Principal Investigator.

Sponsor: Gift for cardiovascular research administered by the Hines VA Research Service.  
Total Cost: $40,000  
Role: Principal Investigator.

**NON-PEER REVIEWED (SPONSORED CLINICAL TRIALS)**

1999-2000  Project: **Antithrombin III in Patients with Severe Sepsis. A Multinational, Double-Blind, Randomized, Placebo-Controlled Phase-III Study**  
Protocol No. BI51.071/7MN-303SE  
Sponsor: Centeon Pharma GmbH.  
Sponsor Representative: PPD Pharmaco International.  
Role: Principal Investigator at North Chicago VA.

1999-2000  Project: **Linezolid (PNU-100766) in the Treatment of Patients with Nosocomial Pneumonia: A Double-Blind, Randomized, Comparator-Controlled Study**  
Protocol No. M/1260/0048  
Sponsor: Pharmacia & Upjohn.  
Role: Sub-Investigator at North Chicago VA.  
Principal Investigator: Frank A. Maldonado, MD.

Sponsor: SmithKine Beecham.  
Role: Principal Investigator at North Chicago VA.
2000-2001  Project: A Randomized, Double-Blind, Double-Dummy, Multicenter, Parallel Group Study to Assess the Efficacy and Safety and Tolerability of Intravenous Gemifloxacin Followed by Oral Levofloxacin versus Intravenous Ceftriaxone Followed by Oral Levofloxacin in the Treatment of Nosocomial Pneumonia (NP) in Adults at Low Risk for Infection with Pseudomonas Aeroginosa
Sponsor: SmithKine Beecham.
Role: Sub-Investigator.
Principal Investigator: Frank A. Maldonado, MD.

2000-2001  Project: A Randomized, Double-Blind, Phase III, Comparative Study of Cidecin™(Daptomycin)to Rocephin® (Ceftriaxone) in the Treatment of Moderate to Severe Community-Acquired Acute Bacterial Pneumonia Due to S. Pneumoniae
Sponsor: Cubist Pharmaceuticals
Role: Sub-Investigator.
Principal Investigator: Ashok M. Fulambarker, MD.

2008-2010  Project: CV185030: A Phase III, Active (Warfarin) Controlled, Randomized, Double-Blind, Parallel Arm Study to Evaluate Efficacy and Safety of Apixaban in Preventing Stroke and Systemic Embolism in Subjects with Nonvalvular Atrial Fibrillation (ARISTOTLE)
Sponsor: Bristol Myers Squibb.
Total Cost: $415,245 (target 19 patients).
Role: Principal Investigator at the North Chicago VA Medical Center.

2008-2010  Project: A Multi-center, Randomized, Double-Blind, Placebo-Controlled Study to Evaluate the Safety and Efficacy of SCH 530348 in Addition to Standard of Care in Subjects With Acute Coronary Syndrome: Thrombin Receptor Antagonist for Clinical Event Reduction in Acute Coronary Syndrome (TRACER)
Sponsor: Schering-Plough.
Total Cost: $123,809 (target 13 patients).
Role: Principal Investigator at the North Chicago VA Medical Center.

Sponsor: Schering-Plough.
Total Cost: $85,000 (target 17 patients).
Role: Principal Investigator at the North Chicago VA Medical Center.

2008-2010  Project: A Phase 3 Randomized, Double-blind, Parallel-group, Multi-center Study of the Safety and Efficacy of Apixaban for Prophylaxis of Venous Thromboembolism in Acutely Ill Medical Subjects During and Following Hospitalization
Sponsor: Bristol Myers Squibb.
Total Cost: $40,766.90 (target 5 patients).
Role: Principal Investigator at the North Chicago VA Medical Center.
2008-2010  Project: Stabilization Of pLaques usIng Darapladib” - A Clinical Outcomes Study of Darapladib versus Placebo in Subjects Following Acute Coronary Syndrome to Compare the Incidence of Major Adverse Cardiovascular Events (MACE) (SOLID TIMI 52 )  
Sponsor: GlaxoSmithKline LLC.  
Total Cost: $91,125. (target 10 patients).  
Role: Principal Investigator at the North Chicago VA Medical Center.

GIFTS

2004-2005  Project: Unrestricted Gift in Support of Industrial Partnership  
Donor: Aventis Pharma Deutschland GmbH  
Total Gift: $50,000.  
Role: Principal Investigator.

2004-2005  Project: Gift for Research and Education of First Responders to Victims of a Heart Attack  
Donor: The Curtis I. Kossman Foundation  
Total Cost: $50,000.  
Role: Principal Investigator.

2005-2006  Project: Gift for Research Activities  
Donor: Pediatric Critical Care Specialists, P.C.  
Total Cost: $7,000.  
Role: Principal Investigator.

2005-2007  Project: Gift for Research and Education of First Responders to Victims of a Heart Attack  
Donor: The Curtis I. Kossman Foundation  
Annual Gift: $55,000.  
Role: Principal Investigator.

2008-2009  Project: Unrestricted Gift to Support Resuscitation Research  
Donor: Michael G. Klug and Marie Kube  
Total Gift: $5,000.  
Role: Principal Investigator.

2011  Project: Unrestricted Funds to Support Educational and Research Activities  
Donor: ZOLL Medical Corporation  
Total Gift: $12,000  
Role: Principal Investigator.

2013  Project: Unrestricted Funds for Cardiac Research  
Donor: Monica Ply  
Total Gift: $32,500  
Role: Principal Investigator.