THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

81ST ANNUAL MEETING

WALDORF ASTORIA ROME CAVALIERI

SEPTEMBER 18-21, 2019

American Association of Neurological Surgeons

Jointly Provided by the AANS

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

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FUTURE MEETINGS

September 23-27, 2020
Broadmoor Hotel
Colorado Springs, Colorado

2021
TBA

2002
TBA

Mark your calendars now!

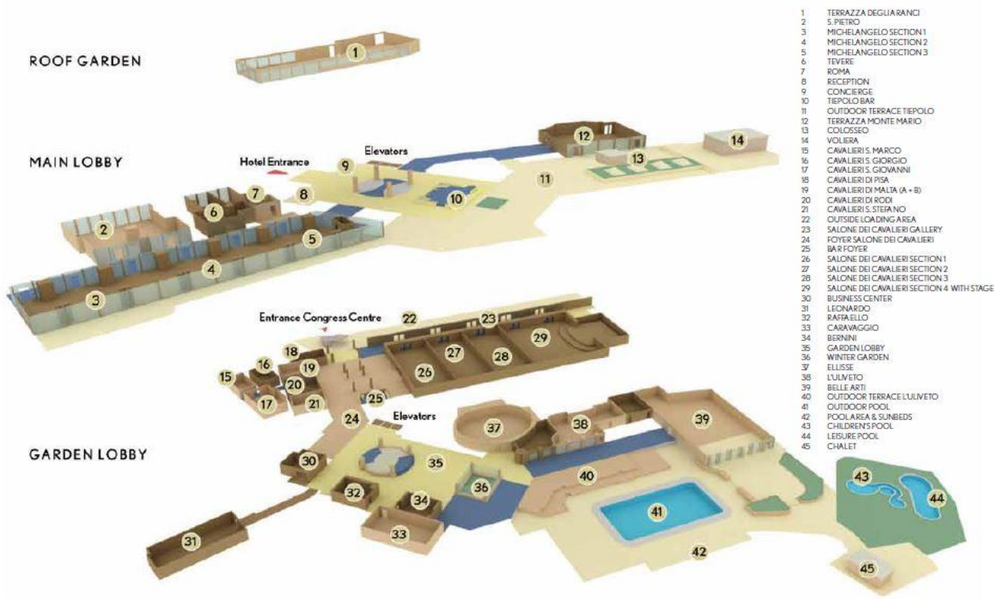
General Information

Hotel Information

Rome Cavalieri Waldorf Astoria
Via Alberto Cadlolo
101, 00136 Roma RM, Italy
Phone: +39.06.35091
Website: *www.romecavalieri.com*

Registration Location:	**Hospitality Desk San Pietro** (Lobby right hand corridor)
Registration Hours:	
Wednesday, September 18	10:00 am – 5:00 pm
Thursday, September 19	6:30 am – 2:00 pm
Friday, September 20	6:30 am – 2:00 pm
Saturday, September 21	7:00 am – 11:00 am

ROME CAVALIERI
WALDORF ASTORIA HOTELS & RESORTS



1 TERRAZZA DEGLI ARANCI
2 S. PIETRO
3 MICHELANGELO SECTION 1
4 MICHELANGELO SECTION 2
5 MICHELANGELO SECTION 3
6 TEVERE
7 ROMA
8 RECEPTION
9 CONCIERGE
10 TIEPOLO BAR
11 OUTDOOR TERRACE TIEPOLO
12 TERRAZZA MONTE MARIO
13 COLOSSEO
14 VOLIERA
15 CAVALIERI S. MARCO
16 CAVALIERI S. GIORGIO
17 CAVALIERI S. GIOVANNI
18 CAVALIERI DI PISA
19 CAVALIERI DI MALTA (A + B)
20 CAVALIERI DI RODI
21 CAVALIERI S. STEFANO
22 OUTSIDE LOADING AREA
23 SALONE DEI CAVALIERI GALLERY
24 FOYER SALONE DEI CAVALIERI
25 BAR FOYER
26 SALONE DEI CAVALIERI SECTION 1
27 SALONE DEI CAVALIERI SECTION 2
28 SALONE DEI CAVALIERI SECTION 3
29 SALONE DEI CAVALIERI SECTION 4 WITH STAGE
30 BUSINESS CENTER
31 LEONARDO
32 RAFFAELLO
33 CARAVAGGIO
34 BERNINI
35 GARDEN LOBBY
36 WINTER GARDEN
37 ELLISSE
38 L'ULIVETO
39 BELLE ARTI
40 OUTDOOR TERRACE L'ULIVETO
41 OUTDOOR POOL
42 POOL AREA & SUNBEDS
43 CHILDREN'S POOL
44 LEISURE POOL
45 CHALET

# Map	Location
2	Registration
3	Scientific Sessions
6	Office
12	Member Breakfast/Business Meeting
36	Guest/Spouse Breakfast

A Special Thanks
to the following exhibitors supporting the

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY
81ST ANNUAL SCIENTIFIC MEETING

Please take time to visit with them during the Break
in the Sala San Pietro

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THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

81ST ANNUAL SCIENTIFIC MEETING
WALDORF ASTORIA CAVALIERI, ROME ITALY
PROGRAM SUMMARY

WEDNESDAY, SEPTEMBER 18

10:00 am –5:00 pm	Registration	Hospitality Desk, San Pietro
1:00 – 5:30 pm	**Italian Neurosurgical Society/AAcNS Combined Scientific Program**	Sala Michelangelo
7:30 – 10:00 pm	Welcome Reception	Terrazza Aranci Waldorf Astoria Cavalieri Hotel

THURSDAY, SEPTEMBER 19

6:30 am – 2:00 pm	Registration	Hospitality Desk San Pietro
6:30 – 7:20 am	Members Breakfast & Business Meeting	Sala Terrazza Monte Mario
7:00 – 9:00 am	Guest & Spouse Breakfast	L'Uliveto Restaurant
7:30 am – 1:00 pm	**General Scientific Session I**	Sala Michelangelo
12:00–12:50 pm	Intro of Special Lecturer – Nate Selden *The Rhetoric of Medicine: Lessons on Professionalism From Ancient Greece* - Nigel Nicholson	Sala Michelangelo
1:00 – 5:00 pm	Afternoon Activities & Tours	
5:30 pm 6:00 –10:00 pm	*Buses leave hotel* Private Visit to Musei Vaticani & Sistine Chapel Dinner at Paolo VI Residence & Terrace	Vatican City

FRIDAY, SEPTEMBER 20

6:30 am – 2:00 pm	Registration	Hospitality Desk San Pietro
6:30 – 7:20 am	Members Breakfast & Business Meeting	Sala Terrazza Monte Mario
7:00 – 9:00 am	Guest & Spouse Breakfast	L'Uliveto Restaurant
7:30 am – 1:45 pm	**General Scientific Session II**	Sala Michelangelo
11:50 - 12:20 pm	Intro to Special Lecture: Alessandro Olivi *Fast cars and fast trains: The Ferrari and Italo stories* – Luca di Montezemolo	Sala Michelangelo
12:20 - 1:20 pm	Introduction to Presidential Address: Mark Johnson ***Quo Vadis, Academia?*** – E. Antonio Chiocca	Sala Michelangelo
1:30 – 5:00 pm	Afternoon Activities & Tours	
6:30 pm	New Member Welcome Reception with AAcNS Executive Committee	Sala Pantheon
7:00 – 12:00 midnight	Gala Dinner	Villa Miani

SATURDAY, SEPTEMBER 21

6:30 – 8:30 am	Members & Guests Breakfast	L'Uliveto Restaurant
7:00 – 11:00 am	Registration	Hospitality Desk San Pietro
7:30 am – 12:00	**General Scientific Session III**	Sala Michelangelo
7:35 – 8:05 am	Oldfield Lecture – Amy Heimberger	Sala Michelangelo
8:55 – 9:30 am	Intro to Special Lecture: Alessandro Olivi *Thirty generations of winemaking and still feeling young* – Lamberto Frescobaldi	Sala Michelangelo
12:30 pm	Wine tasting with Lamberto Frescobaldi	Sala Michelangelo

Meeting Adjourned

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

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M. Sean Grady, MD

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Aviva Abosch, MD
Sepideh Amin-Hanjani, MD
Alexandra Golby, MD

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Quarterly Newsletter
Shenandoah Robinson, MD

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AANS Joint Sponsorship Education Representative
Michael McDermott, MD – Chair

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Christopher Loftus, MD – Second Delegate

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John Sampson, MD
Robert Gross, MD

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Spence Braden	1940	Byron C. Pevehouse	1982
Joseph P. Evans	1941	Sidney Goldring	1983
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Frank H. Mayfield	1943	Thomas Langfitt	1985
A. Earl Walker	1944	Phanor L. Perot, Jr	1986
Barnes Woodhall	1946	Shelley N. Chou	1987
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Henry G. Schwartz	1952	George Tindall	1993
J. Lawrence Pool	1953	William A. Buchheit	1994
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David L. Reeves	1955	John M. Tew, Jr	1996
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Jess D. Herrmann	1958	J. Charles Rich	1999
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George S. Baker	1960	Roberto C. Heros	2001
C. Hunter Shelden	1961 - 62	Donald O. Quest	2002
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Theodore Rasmussen	1964	Volker K.H. Sonntag	2004
Edmund J. Morrissey	1965	Martin B. Camins	2005
George Maltby	1966	L. Nelson Hopkins	2006
Guy L. Odom	1967	Richard Morawetz	2007
James G. Galbraith	1968	Robert F. Spetzler	2008
Robert H. Pudenz	1969 - 70	Ralph G. Dacey, Jr.	2009
William B. Scoville	1971	Steven Giannotta	2010
Robert L. McLaurin	1972	Robert A. Solomon	2011
Lyle A. French	1973	James T. Rutka	2012
Benjamin B. Whitcomb	1974	Griffith R. Harsh	2013
John R. Green	1975	Fredric B. Meyer	2014
William H. Feindel	1976	Mitchel S. Berger	2015
William H. Sweet	1977	Mark D. Hadley	2016
Arthur A. Ward	1978	William T. Couldwell	2017
Robert B. King	1979	Daniel L. Barrow	2018
Eben Alexander, Jr.	1980		

Past Vice-Presidents

Francis Murphey	1941	Hugo V. Rizzoli	1983
William S. Keith	1942	James W Correll	1984
John Raaf	1943	E. Bruce Hendrick	1985
Rupert B. Raney	1944	Griffith R Harsh, III	1986
Arthur R. Elvidge	1946	Ellis B Keener	1987
F. Keith Bradford	1949	Robert Grossman	1988
David L Reeves	1950	Jim Story	1989
Henry G. Schwartz	1951	John Jane, Sr.	1990
J. Lawrence Pool	1952	Stewart Dunsker	1991
Rupert B. Raney	1953	Burton M Onofrio	1992
David L. Reeves	1954	Martin H Weiss	1993
Stuart N. Rowe	1955	John M. Tew, Jr.	1994
Jess D. Hermann	1956	John C. VanGilder	1995
George S. Baker	1957	Edward Connolly	1996
Samuel R. Snodgrass	1958	George Ojemann	1997
C. Hunter Shelden	1959	Charles H. Tator	1998
Edmund Morrissey	1960	Donald O. Quest	1999
Donald F. Coburn	1961 - 62	Howard M. Eisenberg	2000
Eben Alexander, Jr.	1963	Richard B. Morawetz	2001
George L Maltby	1964	Martin B. Camins	2002
Robert Pudenz	1965	Arthur L. Day	2003
Francis A. Echlin	1966	William F. Chandler	2004
Benjamin Whitcomb	1967	Steven L. Gianotta	2005
Homer S. Swanson	1968	Robert F. Spetzler	2006
Augustus McCravey	1969 - 70	Griffith R. Harsh IV	2007
Edward W. Davis	1971	Daniel L. Barrow	2008
John R. Green	1972	M. Sean Grady	2009
George J. Hayes	1973	Warren Selman	2010
Richard L. DeSaussure	1974	Jeffrey Bruce	2011
Ernest W. Mack	1975	James Drake	2012
Frank E. Nulsen	1976	Corey Raffel	2013
Robert S. Knighton	1977	Alan R. Cohen	2014
Robert G. Fisher	1978	Michael T. Lawton	2015
H Thomas Ballantine, Jr.	1979	James M. Markert, Jr.	2016
George Ehni	1980	Robert Harbaugh	2017
Courtland H. Davis, Jr.	1981	Nelson M. Oyesiku	2018
John F. Mullan	1982		

Past Secretary-Treasurers

Francis Murphey	1938 - 40
A. Earl Walker	1941 - 43
Theodore C. Erickson	1944 - 47
Wallace B. Hamby	1948 - 50
Theodore B. Rasmussen	1951 - 53
Eben Alexander	1954 - 57
Robert L. McLaurin	1958 - 62
Edward W. Davis	1963 - 65
Robert G. Fisher	1966 - 68
Byron C. Pevehouse	1969 - 72

Past Secretaries

Byron C. Pevehouse	1973
Russel H. Patterson, Jr	1974 - 1976
Phanor L. Perot, Jr	1977 - 1980
John T. Garner	1981 - 1983
James T. Robertson	1984 - 1986
Nicholas T. Zervas	1987 - 1989
William A. Buchheit	1990 - 1992
Julian T. Hoff	1992 - 1995
Roberto C. Heros	1995 - 1998
David G. Piepgras	1999 - 2001
L. Nelson Hopkins	2002 - 2004
Ralph G. Dacey, Jr	2005 - 2007
James Rutka	2008 - 2010
Mitchel S. Berger	2011 - 2013
Daniel L. Barrow	2014 - 2017
James M. Markert, Jr.	2018 –2021

Past Treasurers

Russel H. Patterson, Jr.	1973
Phanor L. Perot, Jr	1974 - 1976
John T. Garner	1977 - 1980
James T. Robertson	1981 - 1983
Nicholas T. Zervas	1984 - 1986
William A. Buchheit	1987 - 1989
Julian T. Hoff	1990 - 1992
Roberto C. Heros	1992 - 1995
David G. Piepgras	1996 - 1998
L. Nelson Hopkins	1999 - 2001
Ralph G. Dacey, Jr.	2002 - 2004
James T. Rutka	2005 - 2007
Griffith Harsh	2008 - 2010
Daniel L. Barrow	2011 - 2013
E. Antonio Chiocca	2014 – 2017
Douglas Kondziolka	2018 – 2021

Academy Award Winners

Paul M. Lin	1955	L. Brannon Thomas	1995
Hubert L. Rosomoff	1956	John S. Yu	1996
Byron C. Pevehouse	1957	Gregory Canute	1997
Norman Hill	1958	Nathan R. Selden	1998
Jack Stern	1959	Robert M. Friedlander	1999
Robert Ojemann	1960	Tien T. Nguyen	2000
Lowell E. Ford	1962	Peng Chen	2001
Charles H. Tator	1963	Ganesh Rao	2002
Earle E. Crandall	1964	Gelareh Zadeh	2003
Stephen Mahaley, Jr	1965	Eric C. Leuthardt	2004
Chun Ching Kao	1966	Manish Aghi	2005
John P. Kapp	1967	Alfred T. Ogden	2006
Yoshio Hosobuchi	1968	Paul Kongkham	2007
Gary G. Ferguson	1970	Elias Rizk	2008
Richard L. Pressley	1971	Costas Hadjipanayis	2009
David G. McLone	1972	Scellig Stone	2010
Arden F. Reynolds, Jr.	1973	Paul S.A. Kalanithi	2011
Richard L. Rapport	1974	Derek G. Southwell	2012
Andrew G. Shetter	1975	Nader Sanai	2013
John R. Howe	1976	Hani Malone	2014
Howard W. Blume	1977	Achal Achrol	2015
Howard J. Senter	1978	Eyiyemisi Damisah	2016
Elisabeth M. Post	1979	Teresa Purzner	2017
David Dubuisson	1980	Pier Paolo Peruzzi	2018
Dennis A. Turner	1981	Davide Giampiccolo (It)	2019
Marc R. Mayberg	1982	Ben Grannan (US)	2019
David S. Baskin	1983		
Kevin J. Kiwak	1984		
Terry Lichtor	1985		
Michael G. Nosko	1986		
Joseph R. Madsden	1987		
James T. Rutka	1988		
Christopher D. Heffner	1989		
Scott I. Gingold	1990		
Mary Louise Hlavin	1991		
Adam P. Brown	1992		
Michael Tymianski	1993		
David Garrett, Jr.	1994		

Meetings Of The Academy

Hotel Netherland Plaza, Cincinnati, Ohio	October 28 - 29, 1938
Roosevelt Hotel, New Orleans, Louisiana	October 27 - 29, 1939
Tudor Arms Hotel, Cleveland, Ohio	October 21 - 22, 1940
Mark Hopkins Hotel, San Francisco, California	November 11 - 15, 1941
Ambassador Hotel, Los Angeles, California	November 11 - 15, 1941
The Palmer House, Chicago, Illinois	October 16 - 17, 1942
Hart Hotel, Battle Creek, Michigan	September 17 - 18, 1943
Ashford General Hospital, White Sulphur Springs, West Virginia	September 7 - 9, 1944
The Homestead, Hot Springs, Virginia	September 9 - 11, 1946
Broadmoor Hotel, Colorado Springs, Colorado	October 9 - 11, 1947
Windsor Hotel, Montreal, Canada	September 20 - 22, 1948
Benson Hotel, Portland, Oregon	October 25 - 27, 1949
Mayo Clinic, Rochester, Minnesota	September 28 - 30, 1950
Shamrock Hotel, Houston, Texas	October 4 - 6, 1951
Waldorf-Astoria Hotel, New York City, New York	September 29 - October 1, 1952
Biltmore Hotel, Santa Barbara, California	October 12 - 14, 1953
Broadmoor Hotel, Colorado Springs, Colorado	October 21 - 23, 1954
The Homestead, Hot Springs, Virginia	October 27 - 29, 1955
Camelback Inn, Phoenix, Arizona	November 8 - 10, 1956
The Cloister, Sea Island, Georgia	November 11 - 13, 1957
The Royal York Hotel, Toronto, Canada	November 6 - 8, 1958
Del Monte Lodge, Pebble Beach, California	October 18 - 21, 1959
Copley Sheraton Plaza, Boston, Massachusetts	October 5 - 8, 1960
Royal Orleans, New Orleans, Louisiana	November 7 - 10, 1962
El Mirador, Palm Springs, California	October 23 - 26, 1963
The Key Biscayne, Miami, Florida	November 11 - 14, 1964
Terrace Hilton Hotel, Cincinnati, Ohio	October 14 - 16, 1965
Fairmont Hotel & Towers, San Francisco, California	October 17 - 19, 1966
The Key Biscayne, Miami, Florida	November 8 - 11, 1967
Broadmoor Hotel, Colorado Springs, Colorado	October 6 - 8, 1968
St. Regis Hotel, New York City	September 21, 1969
Camino Real, Mexico City, Mexico	November 18 - 21, 1970
Sahara-Tahoe Hotel, Stateline, Nevada	September 26 - 30, 1971
New College, Oxford, England	September 4 - 7, 1972
Huntington-Sheraton Hotel, Pasadena, California	November 14 - 17, 1973
Southampton Princess Hotel, Bermuda	November 6 - 9, 1974
The Wigwam (Litchfield Park), Phoenix, Arizona	November 5 - 8, 1975
Mills Hyatt House, Charleston, South Carolina	November 10 - 13, 1976
Mauna Kea Beach Hotel, Kamuela, Hawaii	November 2 - 5, 1977
Hotel Bayerischer Hof, Munich, Germany	October 22 - 25, 1978
Hyatt Regency, Memphis, Tennessee	November 7 - 10, 1979
Waldorf-Astoria Hotel, New York City, New York	October 1 - 4, 1980
Sheraton Plaza, Palm Springs, California	November 1 - 4, 1981
Ritz-Carlton Hotel, Boston, Massachusetts	October 10 - 13, 1982
The Lodge at Pebble Beach, California	October 23 - 26, 1983
The Homestead, Hot Springs, Virginia	October 17 - 20, 1984
The Lincoln Hotel Post Oak, Houston, Texas	October 27 - 30, 1985
The Cloister, Sea Island, Georgia	November 5 - 8, 1986
Hyatt Regency, San Antonio, Texas	October 7 - 10, 1987
Omni Netherland Plaza, Cincinnati, Ohio	September 13 - 17, 1988
Loews Ventana Canyon, Tucson, Arizona	September 27 - October 1, 1989
Amelia Island Plantation, Amelia Island, Florida	October 2 - 7, 1990
Salishan Lodge, Gleneden Beach, Oregon	September 22 - 26, 1991
Ritz-Carlton Hotel, Naples, Florida	October 21 - 25, 1992
The Wigwam, Phoenix, Arizona	October 27 - 30, 1993
The Cloister, Sea Island, Georgia	November 3 - 6, 1994
Loews Ventana Canyon Resort, Tucson, Arizona	November 1 - 5, 1995
The Greenbrier, White Sulphur Springs, WV	September 18 - 22, 1996
Rimrock Resort, Banff, Alberta, Canada	September 10 - 14, 1997
Four Seasons Biltmore, Santa Barbara, California	November 4 - 7, 1998
Ritz-Carlton, Amelia Island, Florida	November 10 - 13, 1999
The Broadmoor, Colorado Springs, Colorado	October 11 - 14, 2000
The Breakers, Palm Beach, Florida	November 14 - 17, 2001
The Phoenician, Scottsdale, Arizona	October 16 - 19, 2002

Colonial Williamsburg, Williamsburg, Virginia	October 29 - November 1, 2003
Four Seasons Berlin & Hotel Taschenbergpalais, Dresden, Germany	October 3 - 8, 2004
Ritz-Carlton, Half Moon Bay, California	September 21 - 24, 2005
Ritz-Carlton, Reynolds Plantation, Greensboro, GA	October 18 - 21, 2006
Ritz-Carlton, Lake Las Vegas, Nevada	October 31 - November 3, 2007
Barrow Neurological Institute Phoenix; Enchantment Resort, Sedona Arizona	September 10 - 13, 2008
The Breakers, Palm Beach, Florida	November 4 - 7, 2009
The Inn at Spanish Bay, Pebble Beach, California	November 3 - 6, 2010
The Fairmont Scottsdale Princess, Scottsdale, AZ	October 19 - 22, 2011
The Chatham Bars Inn, Chatham, Massachusetts	October 17 - 20, 2012
The Resort at Pelican Hill, Newport Coast, CA	September 25 - 28, 2013
WaterColor Inn & Resort, Santa Rosa Beach, FL	September 17 - 20, 2014
Hotel Europäischer Hof, Heidelberg, Germany	October 7 - 10, 2015
Four Seasons Resort, Jackson Hole, Wyoming	September 14 - 17, 2016
Four Seasons Santa Barbara, Santa Barbara, CA	September 13 – 16, 2017
The Breakers, Palm Beach, Florida	October 24 – 27, 2018
Rome Cavalieri Waldorf Astoria, Rome, Italy	September 18-21, 2019

MISSION STATEMENT

The purpose of the Academy meeting shall be to promote scientific and social interaction among its members, to foster neurological surgery as a specialty of medicine, to encourage and sponsor basic and clinical research activity in the neurological sciences, and to promote the knowledge and skill of those who devote themselves to neurological surgery in accordance with the high ideals of the medical profession.

This activity will include live presentations from faculty to include case presentations and discussion, as well as time for questions and answers.

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

American Association of Neurological Surgeons
Jointly Provided by the AANS

LEARNING OBJECTIVES

- Describe the implications of modern genomics for brain tumor diagnosis, natural history and treatment, hydrocephalus, and degenerative spinal disorders
- Identify novel applications for therapeutic devices in the nervous system, including intravascular therapy for stroke, hemorrhage, and hydrocephalus, and functional surgery applications beyond movement disorders
- Define the impact of health care systems on quality of care in head trauma, spinal surgery and general neurosurgery.

ACCREDITATION STATEMENT

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the AANS and the American Academy of Neurological Surgery. The AANS is accredited by the ACCME to provide continuing medical education for physicians.

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The AANS designates this live activity for a maximum of 17.75 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Link for CME reporting will be sent to you via email following the meeting.

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INTENDED AUDIENCE/BACKGROUND REQUIREMENT

The scientific program presented is intended for neurosurgeons either in training or in active practice.

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Charles Branch	Consultant	Medtronic Spine, Olympus
Henry Brem	Grants/Research Industry Grant Support Consultant	NIH, Johns Hopkins University Arbor Pharmaceuticals, Bristol-Myers Squibb, Acuity Bio Corp AsclepiX Therapeutics, StemGen, InSightec, Accelerating Combination Thearpies, Camden Partners, LikeMinds Galen Robotics, Nurami Medical
Fady Charbel	Consultant	Transonic, Inc
*E. Antonio Chiocca	Industry Grant Support	Advantagene Inc, New Link Genetics
E. Sander Connolly	Grants/Research Support	NIA, NINDS, AHRQ
G. Rees Cosgrove	Industry Grant Support Consultant Stockholder	Insightec Inc Voyager Therapeutics, Inc. Tivorsan Inc, Watermark Inc.
*William Couldwell	Grants/Research	Dumke Foundation
Rose Du	Honorarium	Oakstone
Howard Eisenberg	Grants/Research Industry Grant Support Consultant	FUS Foundation Insigntee NFL
*Richard Ellenbogen	Grants/Research	NIH/NINDS
Michael Fehlings	Consultant	Fortuna FIX
Richard G. Fessler	Consultant	DePuy-Synthes, Benvenue
Kevin T. Foley	Consultant Shareholder	Medtronic Digital Surgery Systems, Discgenics, DuraStat, LaunchPad Medical, Medtronic, NuVasive, Practical Navigation/Fusion Robotics, SpineWave, TDi, Triad Life Services
Robert Friedlander	Consultant/Shareholder	NeuBase Therapeutics
Paul A. Gardner	Consultant Stockholder	Zeiss Spiway
Zoher Ghogawala	Grants/Research Support Stock & Intellectual Property	NIH, PCORi Nidus, Inc
*Alexandra Golby	Stockholder	Merck & Co., Johnson & Johnson
Benjamin Grannan	Grants/Research Support	NREF Fellowship, NIH T32
Gerald Grant	Grants/Research Support Honorarium	NIH, Emerson Cancer Award, PAC=12 Integra Lifesciences
Regis Haid Jr.	Consultant Shareholder	NuVasive NuVasive, Glbus Medical, Paradigm Spine, SpineWave, Vertical Health
Robert Harbaugh	Consultant Shareholder	Actuated Medical Inc, NeurExcel Therapeutics Inc Nanower Inc,
Amy Heimberger	Industry Grant Support Stockholder	Merck Caris Life Science
Judy Huang	Stockholder	Longeviti
Steven Kalkanis	Consultant Stockholder	Arbor Pharma, Synaptive Medical Synaptive Medical
*Douglas Kondziolka	Grant/Research Support	NIH, Brainlab AB
Frederick Lang	Honorarium	NXDX, InsightTEC
Michael T. Lawton	Consultant	Zeiss, Stryker
Allan Levi	Honorarium	Medtronic
Elad Levy	Industry Grant Support Consultant/Shareholder Honorarium	Medtronic, SWIFT Prime, SWIFT Direct Claret Medical, GLG Consulting, Guideoint Global, Imperative Care, Medtronic, Rebound Therapeutics, StimMed Medtronic
Andres Lozano	Consultant	Medtronic St. Jude, Boston Scientific
[A]*James M Markert Jr.	Grants/Research Support Stock or Shareholder Other Financial Support/Shareholder	NIH, Gateway, DoD Aettis Inc, Treovir Inc Catherex
Michael McDermott	Consultant	Stryker
Ehud Mendel	Honorarium	DePuy-Synthes

Name	Type of Disclosure	Entity/Company
Jacques Morcos	Consultant Shareholder	Leica Kogent
Praveen Mummaneni	Industry Grant Support Consultant Stockholder Honorarium	AO Spine, ISSG, NREF Depuy, Stryker, Globus Spinicity AO Spine, Spineart
Raj Narayan	Consultant Stockholder	Scientific Advisory Board Helius Helius
Donald O'Rourke	Grants/Research Support Industry Grant Support Shareholder Other Financial Support	NIH Novartis ISOMA Therapeutics Patents owned by University of PA and NOVARTIS
Wilson Ray, MD	Grants/Research Support Consultant Stockholder	NIH, NINDS, DoD Depuy Synthes, Globus Medical, NerveGen Acera Surgical
Ali Rezai	Shareholder	Neurotechnology Innovation Translator & Management, Solis Therapeutics
Howard Riina	Grants/Research Support Industry Grant Support Shareholder Speakers Bureau	New York University Medtronic NTI, eLum, Medivis, Medtel, INO Armor, Neuromedica Stryker
John H. Sampson	Grants/Research Support Consultant Stockholder	Annias Immunotherapeutics, Istari Oncology Medicenna, Annias Immunotherapeutics, Insera Health Annias Immunotherapeutics, Istari Oncology, Neuronium, Immunomic Therapeutics, Insera Health
*Nathan R. Selden	Stockholder	Oenebrotech
Franco Servedei	Grants/Research support Industry Grant Support Consultant	Humanitas University Fingebatuca Fingebatuca, Integra Life, Tareda

Name	Type of Disclosure	Entity/Company
Adnan H. Siddiqui	Grants/Research Support Consultant *No consulting salary, all done per project or per hour Financial Interest	NIH-NINDS - Amnis Therapeutics, Boston Scientific, Canon Medical Systems USA, Cerebrotech Medical Systems, Cerenovus, Corindus, Integra, Medtronic, MicroVention, Northwest University DSMB Chair for HEAT Trial, Penumbra, Q'apel Medical, Rapid Medical, Rebound Therapeutics, Serenity Medical, Silk Road Medical, StimMed, Stryker, Three Rivers Medical, VasSol, W.L. Gore & Assoc. - Amnis Therapeutics, Blink TBI, Buffalo Technology Partners, Cardinal Consultants, Cerebrotech Medical Systems, Cognition Medical, Endostream Medical, Imperative Care, International Medical Distribution Partners, Neurovascular Diagnostics, Q'Apel Medical, Rebound Therapeutics, Rist Neurovascular, Serenity Medical, Silk Road Medical, Spinnaker Medical, StimMed, Synchron, Three Rivers Medical, Viseon Spine.
Robert F. Spetzler	Stockholder	Boston Scientific, Synergetics, Dicom Grid, EmergMD, Neurovasc, RSB Spine, iCo Therapeutics, Katalyst/ Kogent
Gary Steinberg	Grants/Research Support Consultant Stockholder	NIH NINDS, CIRM Qool Therapeutics; Peter Laszic, US; SanBio NeuroSave
Philip Stieg	Stockholder	BiPad Inc, New Directions Biosciences, ReGen Medicine
Nicholas Theodore	Grants/Research Support Consultant Stockholder	NREF, AO North America Globus Medical Globus Medical
Michael Vogelbaum	Stockholder Honorarium	Infuseon Therapeutics, Inc. Tocagen, Blue Earth Diagnostics, Celgene
Daniel Yoshor	Grants/Research Support Industry Grant Support	NIH, DARPA, VA Second Sight Medical Products
Pascal Zinn	Grants/Research Support Honorarium/Research Support	UPMC Neurosurgery startup funds Co-author Meng Law receives from Bracco Diagnostics

*** Planning Committee**

Those who have reported that they do not have any relationships with commercial interests:

Manish Aghi
Felipe Albuquerque
*Sepideh Amin-Hanjani
*Frederick Barker
*Daniel Barrow
Mustafa Baskaya
Mitchel Berger
Henry Brem
Steven Brem
Paolo Cappabianca
Marco Cenzato
Michelle Clarke
E. Sander Connolly
Roberto Delfini
Alberto Delitala
Franco DeMonte
Robert Dempsey
Francesco DiMeco
Aaron Dumont
Daniel W. Fults
Davide Giampiccolo
Brian Gill
*M. Sean Grady
Jennifer Moliterno Gunel
Mark N. Hadley
*Mark Johnson
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Abhaya Kulkarni
Giuseppe Lanzino
James K. Liu
R. Loch Macdonald
*Debbie Mielke
Nigel Nicholson
Christopher Ogilvy
Alessandro Olivi
Sean Polster
Antonio Raco
Jean Regis
James T. Rutka
Francesco Sala
Mark Shaffrey
Francesco Tomasello
Timothy Ung
Howard L. Weiner
Gregory Zipfel

*=Planning Committee

FACULTY

	Institution | University	City
Manish K. Aghi, MD, PhD	University of California, San Francisco	San Francisco, CA
Felipe Albuquerque, MD	Barrow Brain and Spine	Phoenix, AZ
Sepideh Amin-Hanjani, MD	Neuropsychiatric Institute	Chicago, IL
Mustafa Baskaya	University of Wisconsin	Madison, WI
Bernard Bendok	Mayo Clinic	Phoenix, AZ
Mitchel Berger, MD	University of California SF	San Francisco, CA
Steven Brem, MD	MD Anderson	Houston, TX
Charles Branch	Wake Forest University	Winston-Salem, NC
Paolo Cappabianca	University of Naples	Naples, Italy
Marco Cenzato	Niguarda Hospital	Milan, Italy
Fady Charbel, MD	University of Illinois Chicago	Chicago, IL
E. Antonio Chiocca, MD, PhD	Harvard University	Boston, MA
Michelle Clarke, MD	Mayo Clinic	Rochester, MN
G. Rees Cosgrove, MD	Harvard University	Boston, MA
Franco DeMonte	MD Anderson	Houston, TX
Robert Dempsey, MD	University of Wisconsin	Madison, WI
Francesco DiMeco	Besta NeurosSim Center	Milan, Italy
Rose Du, MD, PhD	Harvard Medical School	Boston, MA
Aaron Dumont, MD	Tulane University	New Orleans, LA
Howard Eisenberg, MD	University of Maryland	Baltimore, MD
Michael Fehlings, MD, PhD	Toronto Western Hospital	Toronto, ON
Richard Fessler, MD	Rush University Medical Center	Chicago, IL
Lamberto Frescobaldi	Marchesi Frescobaldi Group	Florence, Italy
Robert Friedlander, MD	UPMC Presbyterian	Pittsburgh, P
Daniel Fults, MD	University of Utah	Salt Lake City, UT
Paul Gardner, MD	UPMC Presbyterian	Pittsburgh, PA

	Institution | University	City
Zoher Ghogawala, MD	Lahey Hospital & Medical Center	Burlington, MA
Davide Giampiccolo, MD	Academy Award Winner - Italy	Italy
Benjamin Grannan, MD	Massachusetts General Hospital	Boston, MA
Gerald Grant, MD	Stanford University	Stanford, CA
Mark N. Hadley, MD	University of Alabama	Birmingham, AL
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Amy Heimberger	MD Anderson	Houston, TX
Judy Huang	Johns Hopkins University	Baltimore, MD
Mark Johnson	Univ. of Massachusetts Memorial	Boston, MA
Yashar Kalani	University of Virginia	Charlottesville, VA
Steven N. Kalkanis, MD	Henry Ford Neurosurgery	Detroit, MI
Abhaya Kulkarni, MD	University of Toronto	Toronto, ON
Frederick Lang, MD	MD Anderson	Houston, TX
Giuseppe Lanzino, MD	Mayo Clinic	Rochester, MN
Michael Lawton, MD	Barrow Brain & Spine Institute	Phoenix, AZ
Allan Levi, MD	University of Miami	Miami, FL
Elad Levy, MD	University of Buffalo	Buffalo, NY
James Liu, MD	Moffitt Cancer Center	Tampa, FL
Andres M. Lozano, MD, PhD	Toronto Western Hospital	Toronto, ON
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Michael McDermott, MD	University of California SF	San Francisco, CA
James Markert, MD	University of Alabama	Birmingham, AL
Jennifer Moliterno Gunel, MD	Yale University	New Haven, CT
Praveen V. Mummaneni, MD	University of California, San Francisco	San Francisco, CA
Raj K. Narayan, MD	Northwell Neuroscience Institution	Manhasset, NY
Nigel Nicholson, PhD	Reed College	Portland, OR
Christopher Ogilvy, MD	Beth Israel Deaconess Medical Center	Boston, MA
Alessandro Olivi, MD	Instituo di Neurochirurgia	Rome, Italy

	Institution | University	City
Donald M. O'Rourke, MD	University of Pennsylvania	Philadelphia, PA
Sean Polster, MD	University of Chicago	Chicago, IL
Wilson Ray, MD	Washington University in St Louis	St. Louis, MO
Jean Régis, MD	Aix-Marseille Universite,	Marsielle, France
Ali R. Rezai, MD	Rockefeller Neuroscience Institute	Morgantown, WV
Howard Riina, MD	NYU Langone Medical Center	New York, NY
James Rutka, MD, PhD	University of Toronto	Toronto, ON Canada
Francesco Sala	University of Verona	Verona, Italy
John H. Sampson, MD, PhD	Duke University Medical Center	Durham, NC
Franco Servadei	Humanitas University	Milan, Italy
Adnan Siddiqui, MD	University of Buffalo	Buffalo, NY
Gary Steinberg, MD, PhD	Stanford University	Stanford, CA
Philip Stieg, MD	Weill-Cornell Medical College	New York, NY
Nicholas Theodore, MD	Johns Hopkins University	Baltimore, MD
Timothy Ung, MD	University of Colorado	Denver, CO
Michael Vogelbaum, MD	Moffitt Cancer Center	Tampa, FL
Howard Weiner, MD	Brigham and Women's Hospital	Boston, MA
Daniel Yoshor, MD	Baylor College of Medicine	Houston, TX
Pascal Zinn, MD, PhD	University of Pittsburgh	Pittsburgh, PA
Gregory J. Zipfel, MD	Washington University	St. Louis, MO

Guests, Locations & Hosts

Guest	City	Host
Erica Bisson, MD	Salt Lake City UT	William Couldwell
Michelle J. Clarke, MD	Rochester MN	Robert Spinner
Elizabeth Claus	Boston MA	Rose Du
Terry Coyne	St. Paul MN	M. Christopher Wallace
William Curry	Boston MA	Murat Gunel
Amir Dehdashti	Manhasset NY	Raj Narayan
Lamberto Frescobaldi	Florence, Italy	Guest of the Academy
Zoher Ghogawala	Burlington MA	Bob Carter
Davide Giampiccolo, MD	Italy	Academy Award Winner
Benjamin Grannan, MD	Boston MA	Academy Award Winner
Regis Haid Jr. MD	Atlanta GA	Guest of the Academy
Kimberly Harbaugh	Hershey PA	Robert Harbaugh
Judy Huang	Baltimore MD	Henry Brem
Yashar Kalani	Charlottesville VA	Mark Shaffrey
Steven Kalkanis	Detroit MI	Carl Heilman
Kenneth Kishida	Winston-Salem NC	Charles Branch
Adrian Laxton	Winston-Salem NC	Charles Branch
Mark Lee	Morgantown WV	Ali Rezai
John Lee	Philadelphia PA	M. Sean Grady
J Mocco	New York NY	Joshua Bederson
Nigel Nicholson, PhD	Portland OR	Guest of the Academy
Pierpaolo Peruzzi	Boston MA	Guest of the Academy
Andreas Raabe	Bern, Switzerland	Anil Nanda
Violette Recinos	Cleveland OH	Iain Kalfas
Pablo Recinos	Cleveland OH	Iain Kalfas
Takashi Tamiya	Kagawa, Japan	E. Antonio Chiocca
Michael Weaver	Philadelphia PA	Christopher Loftus

Guest	City	Host
Graeme Woodworth	Baltimore MD	Howard Eisenberg
Ted Godfrey	New York NY	Elekta Rep
Tom Brennan	Philadelphia PA	Elekta Rep
Dan Reuvers	Minneapolis MN	Integra Life Science Rep
Michael Tracey	New York NY	Integra Life Science Rep
Meera Gopalakrishnan	Boston MA	Integra Life Science Rep

The American Academy of Neurological Surgery

81st Annual Scientific Meeting
Waldorf Astoria Cavalieri Rome
Scientific Program At A Glance

Wednesday, September 18, 2019

Italian Neurosurgical Society & American Academy of Neurological Surgery - Combined Scientific Program

1:00 – 1:10 Welcome and Introduction
Alex Olivi (Local Arrangements Chair) & Michael McDermott (Scientific Program Chair)

Moderators: Roberto Delfini and Alberto Delitala

1:10 – 1:35 Neurotraumatology and Neurosurgery: A Worldwide Approach
Franco Servadei (*Italy*)

1:40 – 2:00 Trends & New Developments in Glioma Therapy
E. Antonio "Nino" Chiocca (*AAcNS*)

2:05 – 2:25 The Treatment of Pediatric AVMs
Marco Cenzato (*Italy*)

2:30 – 2:45 Trends & New Developments in Endovascular Therapy
Howard Riina (*AAcNS*)

2:45 – 3:05 - BREAK

Moderators: Francesco Tomasello and Antonio Raco

3:10 – 3:30 Endonasal Approaches to Craniopharyngiomas
Paolo Cappabianca (*Italy*)

3:35 – 3:55 Trends & New Developments in Spinal Surgery
Mark Hadley (*AAcNS*)

4:00 – 4:20 Changing Paradigms in Neurosurgical Education. The Case of Virtual Reality and Surgical Simulation
Francesco DiMeco (*Italy*)

4:25 – 4:45 Trends & New Developments in Functional - Epilepsy
G. Rees Cosgrove (*AAcNS*)

4:50 – 5:10 Intraoperative Neurophysiological Monitoring in Spinal Cord Tumor Surgery: How Much Evidence Do We Need?
Francesco Sala (*Italy*)

5:30 Adjourn

Evening Social Event:
Opening Reception ~ 7:30 pm
Terraza Aranci, Waldorf Astoria Cavalieri Hotel
Business Casual Attire recommended

THURSDAY, SEPTEMBER 19, 2019

7:30 – 7:35 WELCOMING REMARKS

Michael McDermott (Scientific Program Chair) & **Alex Olivi** (Local Arrangements Chair)

7:35 – 8:45 **Peer Reviewed Abstract Session I: Functional Science**
Moderators: Daniel Yoshor

7:35 – 7:45 Safety/Efficacy of Bone Marrow-Derived Mesenchymal Stem Cell (SB623) Implantation After Chronic Traumatic Brain Injury
Gary Steinberg

7:45-7:55 Extracellular microRNAs in Blood Differentiate Between Ischemic and Hemorrhagic Stroke
Yasar Kalani

7:55 – 8:05 Hemodynamic Predictors of Long-Term Patency in Cerebral Revascularization Surgery
Fady Charbel

8:05 – 8:15 Early Results of Clinical Testing of a Visual Cortical Prosthetic in Blind Subjects
Daniel Yoshor

8:15 – 8:25 Nerve transfers to improve upper extremity function and quality of life in tetraplegic patients
Wilson Ray

8:25 – 8:35 Mapping brain response patterns to Deep Brain Stimulation with fMRI
Andres Lozano

8:35 – 8:45 Trigeminal Nerve Stimulation as a Neuroprotectant
Raj Narayan

8:45-9:25 **Peer Reviewed Abstract Session II: Spine Science**
Moderators: Nicholas Theodore & Mark Shaffrey

8:45 - 8:55 12-Month Safety and Efficacy Results from the SCiStar Study – A Phase 1/2a Trial of
Richard Fessler

8:55 - 9:05 Early Surgery and Recovery in Central Cord Syndrome: Analysis of 211 Patients from a Prospective, Multi-Center Dataset
Michael Fehlings

9:05 - 9:15 Transpedicular vertebrectomy for thoracic spine metastasis
Ehud Mendel

9:15 - 9:35 Break

9:35-10:45 **Peer Reviewed Abstract Session III: Tumor Science**
Moderators: Nino Chiocca & Mitchel Berger

9:35 - 9:45 Meningioma Genomic Subgroup and Predicting Post-operative Patient Outcomes: Implications for Treatment and Follow-up
Jennifer Moliterno

9:45 - 9:55 Oncolytic G207 Produces immunologic Signature Predicting Response to Therapy
James Markert

9:55 - 10:05 Evolution of Low Grade Gliomas During Malignant Transformation
Mitchel Berger

10:05 - 10:15 Flies, worms and fish: What do these have to do with brain tumours?
Jim Rutka

10:15 - 10:25 Neurosurgical management of sinonasal malignancies involving the skullbase. A 25-year experience.
Franco DeMonte

10:25 - 10:35 Opening of blood brain barrier in the hippocampus and entorhinal cortex in Alzheimer's disease with focused ultrasound
Ali Rezai

10:35 - 10:45 CAR T cell therapy for glioblastoma: Current observations and future directions
Don O'Rourke

10:50-11:50 **Peer Reviewed Abstract Session 4: Vascular Science**
Moderators: Elad Levy & Robert Spetzler

10:50 - 11:00 Functional Connectivity Deficits After Subarachnoid Hemorrhage
Greg Zipfel

11:00 - 11:10 Microbiome Signatures of Cavernous Angioma
Sean Polster

11:10 - 11:20 The New Generation Hydrogel Endovascular Aneurysm Treatment Trial (HEAT): Final Results
Bernard Bendok

11:20 - 11:30 The R2eD AVM score: a novel predictive tool for arteriovenous malformation presentation with hemorrhage
Judy Huang

11:30-11:40 Cerebral Aneurysm Formation and Rupture: Role of Nrf2 Signaling
Aaron Dumont

11:40 - 11:50 Early Gene Deletion Generates a High-Fidelity Transgenic Mouse Model of Familial Brain Arteriovenous Malformations
Michael Lawton

11:50 - 12:00 Break

12:00 - 12:50 **Special Lecture I**
Moderator: Alex Golby / James Rutka
The Rhetoric of Medicine: Lessons on Professionalism From Ancient Greece
Nate Selden/Nigel Nicholson

Evening Social Event:
Visit to the Musei Vaticani and Sistine Chapel
Dinner at the Paolo VI Residence and Terrace
Buses depart from hotel at 5:30 pm- Business casual attire recommended

FRIDAY, SEPTEMBER 20, 2019

7:30 – 7:35 WELCOME & REMARKS
Michael McDermott (Scientific Program Chair) & **Alex Olivi** (Local Arrangements Chair)

7:35-8:35 **Peer Reviewed Abstract Session V: Vascular**
Moderators: Michael Lawton & E. Sander Connolly

7:35 – 7:45 Deletions in CWH43 Cause Sporadic Idiopathic Normal Pressure Hydrocephalus
Mark Johnson

7:45-7:55 NEWTON-2: Randomized, Double-blind, Placebo-controlled study of EG 1962 in Aneurysmal Subarachnoid Hemorrhage
R. Loch MacDonald

7:55-8:05 When Flow Diversion Fails: Predictive Factors of Incomplete Aneurysm Occlusion after Pipeline Embolization
Chris Ogilvy

8:05-8:15 Transradial Cerebral Angiography: A Safer Alternative
Felipe Albuquerque

8:15-8:25 Somatic mutations in cerebral aneurysms
Rose Du

8:25-8:35 Intracranial Aneurysms: Does Size Really Matter?
Phil Stieg

8:35-9:15 **Peer Reviewed Abstract Session VI: Tumor**
Moderators: Henry Brem & Don O'Rourke

8:35-8:40 Long-Term Outcomes in the Treatment of Pediatric Skull Base Chordomas
Paul Gardner

8:40-8:50 MRI Perfusion Radiomic Machine Learning Identifies Pseudoprogression in Glioblastoma – A Multicenter Study
Pascal Zinn

8:50-9:00 The evolution of epilepsy surgery for children: lessons from tuberous sclerosis complex over 20 years
Howard Weiner

9:00-9:10 Stimulated Raman Histology for Rapid Neurosurgical Intraoperative Histology: A Prospective Series
Allan Levi

9:10-9:20 Role of Visual Cortex in Essential Tremor
Jean Regis

9:20-9:30 Break

9:30-10:30 Peer Reviewed Abstract Session VII: Spine
Moderators: Kevin Foley & Praveen Mummaneni

9:30-9:40 Early Results from the CSM-S RCT: Quality of Life, Cost, and Complications
Zoher Ghogawala

9:40-9:50 Fusion for Spondylolisthesis Is Associated with Greater Improvements: A Multicenter Registry Study
Kevin Foley

9:50-10:00 Frailty, Long-Term Outcomes and Management Implications for Type II Odontoid Fractures in the Elderly
Michelle Clarke

10:00-10:10 The use of intraoperative sodium fluorescein for diagnostic biopsy of intramedullary spine cord lesions
Timothy Ung

10:10-10:20 Robot-Assisted vs Freehand Instrumentation in Short-Segment Lumbar Fusion: Experience with Real-Time, Image-Guided Spinal Robot
Nicholas Theodore

10:20-10:30 Maximal Safe Resection in Thalamic Gliomas is Superior to Biopsy: Personal Reflections on 40 Cases
Mustafa Baskaya

10:30-11:30 Peer Reviewed Abstract Session VIII: Functional/Trauma/Vascular
Moderators: Bernard Bendok / Sepi Amin-Hanjani

10:30-10:40 Dopamine, serotonin, and norepinephrine micro-fluctuations during conscious choice and subjective experience in humans
Charles Branch

10:40-10:50 Intracranially delivered IL-12 secreting CAR T cells recruit host immunity to eradicate heterogeneous GBM
John Sampson

10:50 - 11:00 A New Treatment for Acute TBI – a phase II multicenter trial using novel MRI derivatives as surrogate outcome measures
Howard Eisenberg

11:00-11:10 Dynamic blood brain barrier regulation in mild traumatic brain injury
Gerald Grant

11:10-11:20 Computer-Learning to Identify High Risk Unruptured Aneurysms and Guide Decision Making: Rupture Resemblance Score
Elad Levy

11:20-11:30 Distribution and radiologic features of SEDAVFs in a modern single-center series of patients with spinal vascular shunts
Giuseppe Lanzino

11:30 -11:40 HDFT as a tool to enhance outcomes in the management of hypereloquent lesions
Robert Friedlander

11:40-11:50 Break

11:50-12:20 Special Lecture 2
Moderator: Alex Olivi
Fast cars and fast trains: The Ferrari and Italo stories
Luca di Montezemolo

12:20 - 1:20 Presidential Address
12:20 - 12:30 Introduction of the Academy President : Mark Johnson
12:30 - 1:20 ***Quo Vadis, Academia?***
Nino Chiocca, MD

Evening Social Event:
Academy Gala Dinner
Villa Miani
Attire: Black Tie Optional

7:30 – 8:25 **Special Lecture 3: The Oldfield Lectureship**

7:30 – 7:35 Introduction, Moderator: **Nino Chiocca**

7:35 - 8:05 Oldfield Lecture: Bench to bedside development of a novel STAT3 inhibitor for CNS malignancies - **Amy Heimberger**

8:05 - 8:15 NIH Funding Overview: **Russell Lonser**

8:15 - 8:20 NREF Funding Overview: **Reg Haid**

8:20 - 8:25 AAcNS/NREF Young Clinician Award Update – **Brian JA Gill**

8:25 - 8:30 AAcNS/NREF Research Fellowship Grant Update – **Benjamin Grannan**

8:30 - 8:40 American Academy Young Clinician Investigator Award – North America
Single-cellular representations of semantic meaning during natural language perception
Benjamin L. Grannan

8:40 - 8:50 American Academy Young Clinician Investigator Award – Italy
Monitoring language networks in the asleep patient during surgery: an electrophysiological approach - **Davide Giampiccolo**

8:55 – 9:30 **Special Lecture 4:**

8:55-9:00 Introduction of Academy Special Lecturer: Alex Olivi

9:00-9:30 ***Thirty generations of winemaking and still feeling young***
Lamberto Frescobaldi, President
Azienda Agricola "Marchesi Frescobaldi" Firenze

9:30 - 10:30 **Peer Reviewed Abstract Session 9: Various topics**
Moderators: Jacques Morcos / Robert Harbaugh

9:30-9:40 **Brain growth and developmental outcome after treatment of post-infectious hydrocephalus in infants in Uganda**
Abhaya Kulkarni

9:40-9:50 **Impact on Facial Nerve Outcomes and Extent of Resection Using Subperineural Dissection Technique for Surgical Resection**
James Liu

9:50-10:00 **Phase 0/1 Clinical Trial of Low-Dose Capecitabine in Recurrent GBM: Global Immune Fingerprinting of Tissue and Blood**
Michael Vogelbaum

10:00-10:10 **Sexual Dysfunction: Prevalence, Prognosis, and Predictors of Outcomes in Patients Operated for Lumbar Spondylolisthesis**
Praveen Mummaneni

10:10-10:20 **Cerebro-vascular remodeling following ischemic stroke: cellular and molecular mechanisms.**
Robert Dempsey

10:20-10:30 **Glioblastoma organoids: A model system for patient-specific therapeutic testing**
Steven Brem

10:30-10:45 **Break**

10:45-11:55 **Peer Reviewed Abstract Session 10: Various topics**
Moderators: Michael McDermott / Aviva Abosch

10:45-10:55 **Outcomes from Asleep and Awake Dominant Temporal Lobe Glioma Surgery: Risk, Extent of Resection, and Survival**
Michael McDermott

10:55-11:05 **Real-time CED of Nanoliposomal CPT-11 for recurrent GBM: Interim results of a phase I clinical trial**
Manish Aghi

11:05-11:15 **Leptomeningeal dissemination, a sinister pattern of medulloblastoma growth**
Daniel Fults

11:15-11:25 **Characteristics of Clots Retrieved by Mechanical Thrombectomy Associated with Stroke Etiology and Device Performance**
Adnan Siddiqui

11:25-11:35 **Integration of 5-ALA and CEUS in the Surgical Resection of High Grade Glioma**
Alex Olivi

11:35-11:45 **Mesenchymal Stem Cell Delivery of Oncolytic Adenovirus Delta-24-RGD Following Surgical Resection of Glioblastoma**
Fred Lang

11:45-11:55 **An Epigenetic Liquid Biopsy Machine Learning Algorithm to Predict Glioma and Glioma Subtypes**
Steve Kalkanis

12:00 **Closing Remarks Meeting Adjourn**
2020 Scientific Chair - Aviva Abosch

Immediately following Adjournment, Lamberto Frescobaldi will host a wine tasting entitled "*A Journey Through Tuscany*"

SCIENTIFIC PROGRAM

81ST ANNUAL MEETING OF THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY

WEDNESDAY, SEPTEMBER 18, 2019

ITALIAN NEUROSURGICAL SOCIETY & AMERICAN ACADEMY OF NEUROLOGICAL SURGERY - COMBINED SCIENTIFIC PROGRAM

1:00 – 1:10 **Welcome and Introduction**
Alex Olivi (Local Arrangements Chair) & Michael McDermott (Scientific Program Chair)

Moderators: Roberto Delfini & Alberto Delitala

1:10 – 1:35 **Neurotraumatology and Neurosurgery: A Worldwide Approach**
Franco Servadei (Italy)

1:40 – 2:00 **Trends & New Developments in Glioma Therapy**
E. Antonio "Nino" Chiocca (AAcNS)

2:05 – 2:25 **The Treatment of Pediatric AVMs**
Marco Cenzato (Italy)

2:30 – 2:45 **Trends & New Developments in Endovascular Therapy**
Howard Riina (AAcNS)

2:45 – 3:05 - BREAK

Moderators: Francesco Tomasello & Antonio Raco

3:10 – 3:30 **Endonasal Approaches to Craniopharyngiomas**
Paolo Cappabianca (Italy)

3:35 – 3:55 **Trends & New Developments in Spinal Surgery**
Mark Hadley (AAcNS)

4:00 – 4:20 **Changing Paradigms in Neurosurgical Education. The Case of Virtual Reality and Surgical Simulation**
Francesco DiMeco (Italy)

4:25 – 4:45 **Trends & New Developments in Functional - Epilepsy**
G. Rees Cosgrove (AAcNS)

4:50 – 5:10 **Intraoperative Neurophysiological Monitoring in Spinal Cord Tumor Surgery: How Much Evidence Do We Need?**
Francesco Sala (Italy)

5:30 **Adjourn**

7:30 – 7:35 WELCOMING REMARKS

Michael McDermott (Scientific Program Chair) & **Alex Olivi** (Local Arrangements Chair)

7:35 – 8:45 Peer Reviewed Abstract Session I: Functional Science
Moderators: Robert Gross & Daniel Yoshor

7:35 – 7:45 Safety/Efficacy of Bone Marrow-Derived Mesenchymal Stem Cell (SB623) Implantation After Chronic Traumatic Brain Injury

Albert Lai, Achal Achrol, MD, Alan Weintraub, Susan Paadre, Hideaki Imai, Robert Gross, **Gary Steinberg,** Laroslav Zinkevych, MD, Mena Niakian, David Okonkwo, Takehiko Kaneko, Masahito Kawabori, MD, PhD, Damien Bates, Jefferson Chen, MD, PhD, Peter McAllister, MD, Daniel Lu, Ihor Semeniv, MD, Benjamin Frishberg, MD, Takao Yasuhara

Introduction
Traumatic brain injury (TBI) is a major cause of neurologic disability with no effective treatments.
Objective
This double-blind, randomized, sham-controlled, Phase 2 trial evaluated efficacy and safety of stereotactic intracerebral implantation of allogeneic modified bone marrow-derived mesenchymal stem cells (SB623) in patients with chronic motor deficits secondary to TBI.
Methods
Sixty-one subjects (mean age 34 years) from 18 sites (US, Japan and Ukraine) received 2.5x106, 5.0x106, or 10x106 SB623 cells or sham procedure (1:1:1:1) ratio; n=46 SB623, 15 controls). Primary outcome was mean change from baseline in the Fugl-Meyer Motor Scale (FMMS) of pooled SB623 subjects c/w controls at 24 weeks. MR at 8 days post-implant was evaluated for new FLAIR signal changes.
Results
Mean (SE) change from baseline in FMMS (Week 24) was 8.3 (1.4) for SB623 versus 2.3 (2.5) in the control group (p=0.04). Eight (17.4%) serious adverse events (SAEs) in five (10.9%) SB623-treated subjects occurred versus three (20%) SAEs in three (20%) controls. No abnormal MR FLAIR signal changes were observed in any patients at post-implant Day 8.
Conclusion
The primary efficacy endpoint of improved motor function at 6 months was achieved. SB623 cell implantation was well tolerated. Unlike a prior Phase 1/2a study of patients with chronic ischemic stroke undergoing intracerebral implantation of SB623 cells, where a new transient premotor cortex MR FLAIR signal at 1 week post-implantation was highly correlated with neurologic recovery at 6, 12, and 24 months post-implantation, no new MR FLAIR signal was detected at 1 week post-implant in any of the patients.

7:45-7:55 Extracellular microRNAs in Blood Differentiate Between Ischemic and Hemorrhagic Stroke

Robert Spetzler**, Yashar Kalani**

Introduction
Rapid identification of patients suffering from cerebral ischemia, while excluding intracerebral hemorrhage, can assist with patient triage and expand patient access to chemical and mechanical revascularization.

Objectives
We sought to identify blood-based, extracellular microRNAs (ex-miRNAs) predictive of major stroke subtypes using clinical samples from subjects with intraparenchymal hemorrhage (IPH), subarachnoid hemorrhage (SAH), and ischemic stroke due to cerebral vessel occlusion.
Methods
We collected blood from patients presenting with IPH (n=19), SAH (n=17) and ischemic stroke (n=21). We isolated extracellular vesicles from plasma, extracted RNA cargo, sequenced the small RNAs, and performed bioinformatic analyses to identify ex-miRNA biomarkers predictive of the stroke subtypes.
Results
67 miRNAs were significantly variant across the stroke subtypes. A subset of ex-miRNAs differed between hemorrhagic and ischemic strokes, and LASSO analysis could distinguish SAH from the other subtypes with an accuracy of 0.97 p< 0.002. Further analyses predicted miRNA classifiers that stratify IPH from ischemic stroke with accuracy of 0.81 p< 0.004 and distinguish hemorrhagic from ischemic stroke with accuracy of 0.81 P< 0.003.
Conclusion
Blood-based, ex-miRNAs have predictive value, capable of distinguishing between major stroke subtypes. Such a biomarker may serve as point-of-care tests to rapidly and reliably differentiate between major stroke subtypes and aid with the triage of patients to expand the pool eligible for chemical and mechanical revascularization.

7:55 – 8:05 Hemodynamic Predictors of Long-Term Patency in Cerebral Revascularization Surgery

Christopher Stapleton, Ahmed Hussein, Sepideh Amin-Hanjani, **Fady Charbel**

Introduction
Cerebral revascularization remains an important part of neurovascular surgery, but large cohort analyses with robust hemodynamic data and long-term angiographic follow-up are lacking in the literature.
Objectives
We sought to evaluate hemodynamic factors that predict long-term patency in a large cohort of cerebral bypasses.
Methods
All intracranial bypass procedures performed between 2001 and 2018 were reviewed.
Results
A total of 308 consecutive bypasses were performed during the study period, of which 300 (aneurysm, n=112; atherosclerosis, n=94; moyamoya, n=92) had angiographic follow-up. At a mean follow-up of 2.3 ± 3.0 (range: 0-15.9) years, 225 (75.0%) bypasses were patent. While male sex was associated with long-term bypass patency (patent: 100 [44.4%]; non-patent: 18 [24.0%]; p=0.002), there were no significant differences in patient age (p=0.99), indication for bypass (p=0.81), bypass type (p=0.68), number of bypasses (p=0.21), or number of anastomoses (p=0.45). With respect to hemodynamic factors, there were no significant differences in intra-operative bypass flow (p=0.63), post-operative bypass flow (p=0.41), or ratio of post-operative bypass flow to intra-operative bypass flow (p=0.96). For all EC-IC bypasses (n=223), the cut flow index (CFI), or ratio of bypass flow to donor vessel cut flow, was significantly higher for patent (0.89 ± 0.50) than non-patent (0.71 ± 0.42) bypasses (p=0.008), especially when performed for flow augmentation (i.e., moyamoya or atherosclerosis) purposes (p=0.001).
Conclusion
In this cohort of 300 cerebral revascularization procedures, the CFI was most closely associated with long-term bypass patency, especially when performed for the purpose of flow augmentation.

8:05 – 8:15 Early Results of Clinical Testing of a Visual Cortical Prosthetic in Blind Subjects

William Bosking, **Daniel Yoshor**, Michael Beauchamp, Denise Oswalt

Introduction
It has long been recognized that a visual cortical prosthesis (VCP) has the potential to restore vision to patients with acquired blindness due to damage to the eyes or optic nerves.
Objectives
Here we report on initial findings in the first FDA-approved early feasibility trial of a VCP.
Methods
Two blind subjects at Baylor were implanted with an Orion VCP system, and visual function testing was conducted following implantation.
Results
Using the standard stimulation methods for Orion, subjects demonstrated the ability to locate a bright square on a computer touchscreen. Subject performance was much better using the Orion (3.5-4.5cm) than before implantation or with the system off (12-15cm). One subject also demonstrated the ability to identify the direction of motion of a high contrast bar moving across the touchscreen, with an average error of ~22°, far better than the ~94° average error (chance level performance) with the device off. While the standard Orion settings have not succeeded in produced form vision, we have found that novel electrical stimulation protocols may be used to significantly enhance the functionality of Orion toward this goal . The use of dynamic sequences of stimulation can improve perception of visual forms, and current steering can be effectively used to activate the cortex at a location in between the location of the two physical electrodes.
Conclusion
Early testing of the Orion VCP demonstrate efficacy in performing several basic visual tasks. Novel stimulation paradigms, including the use of dynamic stimulation and current steering, offer the promise of enhanced functionality, including potential for the perception of visual forms.

8:15 – 8:25 Nerve transfers to improve upper extremity function and quality of life in tetraplegic patients

Christopher Dibble, Martin Boyer, **Wilson Ray**, Jawad Khalifeh

Introduction
Spinal cord injury (SCI) is a public health problem. Greater than 50% of SCI occur in the cervical spine resulting in some form of tetraplegia. Recently nerve transfers have been considered as a treatment option to restore upper extremity function in tetraplegic patients.
Objectives
Motor nerve transfers traditionally used to treat peripheral nerve injuries are increasingly used to treat patients with tetraplegia (Figure 1). We present our early results of a prospective clinical trial using nerve transfers to restore upper extremity function in tetraplegia.
Methods
Participants with American Spinal Injury Association (ASIA) A – B cervical SCI) were prospectively enrolled at a single institution and nerve transfer(s) were performed based on pre-operative function and level of injury. Functional recovery and strength were independently assessed and prospectively tracked.
Results
Seventeen participants with a median age of 28.4 years who underwent nerve transfers at a median 18.2 months after injury were included. Median follow-up was 24.9 months. Patients who underwent transfers to median nerve motor branches achieved finger flexion strength MRC 3/5 in 4/15 (26.7%) and wrist flexion strength MRC 3/5 in 5/15 (33.3%) treated upper limbs. Nerve transfers to the posterior interosseous nerve restored MRC 3/5 strength in finger extension in 5/9 (55.6%) and 3/5 strength in thumb extension in 5/9 (55.6%) patients.
Conclusion
Nerve transfers are a promising treatment option to restore upper extremity function in chronic tetraplegia. Our early experience suggests, nerve transfers for the reinnervation of hand and finger flexors provide variable functional recovery. Transfers for the reinnervation of arm, hand, and finger extensors provide more consistent and meaningful return of function.

8:25 – 8:35 Mapping brain response patterns to Deep Brain Stimulation with fMRI

Suresh Joel, Vijayashankar Paramanandam, Mojgan Hodaie, Walter Kucharczyk, David Xu, Sreeram Prasad, Alexandre Boutet, Manish Ranjan, Ailish Coblentz, Jeffrey Ashe, Gavin Elias, Suneil Kalia, Radhika Madhavan, Robert Gramer, Eugen Hlasny, **Andres Lozano**, Alfonso Fasano

Introduction
Deep brain stimulation (DBS) modulates dysregulated brain circuits. Commonly used in Parkinson’s disease (PD), this surgical treatment can produce striking clinical benefits when the stimulation is appropriately programmed. However, DBS programming often requires numerous clinic visits to test the large number of possible stimulation parameters.
Objectives
Here, we examined whether optimal DBS stimulation settings produce a characteristic functional magnetic resonance imaging (fMRI) pattern that could inform DBS programming.
Methods
We performed 3T fMRI in PD patients with either subthalamic nucleus or internal globus pallidus DBS (n=28), obtaining the brain activation patterns with each of the four DBS contacts activated. fMRI brain response patterns to stimulation at clinically determined optimal and non-optimal contacts were compared, and subsequently integrated into a machine learning (ML) framework for optimal contact identification.
Results
Optimal contact stimulation recruited motor areas such as primary motor cortex, thalamus, and anterior cerebellum. In contrast, stimulation through non-optimal contacts resulted in more variable brain circuit engagement accompanied by spillover to non-motor brain areas. The ML model predicted the optimal contact in both previously programmed (76%) and stimulation-naïve patients (75%).
Conclusion
There is a specific and reproducible fMRI brain response pattern in PD-DBS patients at settings associated with optimal clinical benefits. The pattern of fMRI brain responses to stimulation can help elucidate DBS’ mechanism of action and perhaps serve as a step towards more effective programming and improved clinical outcomes.

8:35 – 8:45 Trigeminal Nerve Stimulation as a Neuroprotectant

Chunyan Li, **Raj Narayan**

Introduction
Pharmacological interventions to block cortical spreading depolarization (CSD) typically have significant side effects. Therefore, new strategies are needed to reduce CSDs in the injured brain. The trigeminal nerve is unique because of its intimate connection with cerebral and meningeal blood vessels, referred to as the trigemino-cerebrovascular system. It is also capable of activating the so called ‘diving reflex’, whose primary role is to conserve oxygen for sensitive brain tissue.
Objectives

We aim to investigate the effect of trigeminal nerve stimulation (TNS) to minimize CSD-induced brain injuries.

Methods

Studies were performed on 32 rats. Animals were randomized following middle cerebral artery occlusion (MCAO): (1) control animals with MCAO; (2) MCAO animals with Pre-TNS; (3) MCAO with 3-hour post-TNS (open-loop); (4) MCAO with targeted TNS (closed-loop). The number of CSDs, CBF and oxygen tension were recorded . Brains were collected at 24h after MCAO to measure the lesion volume.

Results

MCAO resulted in a sequence of changes in CBF and DC potentials. Upon occlusion, CBF immediately fell by 68±11%. Spontaneous waves of depolarization appeared in the ischemic penumbra zone, averaging about eight events (8.1±2.1; n=8) over the 3 h after occlusion. The first CSD episode appeared at 7.1±3.6 min after occlusion. TNS significantly lengthened the latency until the appearance of the first CSD almost 7-fold, and decreased their number by 53% (3.8±0.8 vs. 8.2±2.1; n=8). Both open-loop and closed-loop post-TNS also significantly reduced infarction volumes by 47% and 39%, respectively.

Conclusion

Our study demonstrate that TNS can selectively reduce the deleterious consequences of CSDs in the injured brain.

8:45-9:15 Peer Reviewed Abstract Session II: Spine Science

Moderators: Nicholas Theodore & Mark Shaffrey

8:45 - 8:55 12-Month Safety and Efficacy Results from the SCiStar Study – A Phase 1/2a Trial of AST-OPC1

Ed Wirth, **Richard Fessler**, Charles Liu, Gary Steinberg, Shekar Kurpad

Introduction

Spinal cord injury (SCI) causes disruption of motor, sensory, and autonomic function. Cellular transplantation offers a new and promising method of reconstituting the architecture of the damaged cord by providing a permissive substrate, replacing lost cells, enhancing tissue preservation, supporting axonal regeneration, and modulating the inflammatory response.

Objective

The purpose of this study is to evaluate the 12 month outcome data for the 10 million cell AST-OPC1 cohort group in the SCI-Star study.

Methods

The SCiStar study is an open-label, single-arm trial evaluating three escalating doses of AST-OPC1 (2, 10 & 20 million cells) administered to five cohorts of subjects via direct intraparenchymal injection bwtween 21 and 42 days post-SCI. A total of 27 subjects across the five cohorts have been dosed. All subjects in cohort 1 (N=3, 2 million cells) have completed 2 year follow up. All subjects in cohort 2 (N=6 10 million cells) have completed 1 year follow up.

Results

To date, there have been no intraoperative complications or safety issues associated with the cells. No patient demonstrated decreased neurological function or experienced a serious SAE. At 2 year follow up, sujcects in cohort 1 gained 1 motor level relative to baseline. In cohort 2, 100 % of subjects gained at least 1 motor level and 67 % regained two motor levels on at least one side, compared to 26 % in the comparison group.

Conclusion

The results of the SCiStar study demonstrate a strong safety profile. The 2 year efficacy data indicate a dose-dependent increase in recovery of upper extremity motor function.

8:55 - 9:05 Early Surgery and Recovery in Central Cord Syndrome: Analysis of 211 Patients from a Prospective, Multi-Center Dataset

Michael Fehlings, Jefferson Wilson, Jetan Badhiwala

Introduction

There remains a paucity of data on the contemporary outcomes of central cord syndrome (CCS) and their predictors. Further, the efficacy of early surgical decompression for CCS remains unclear.

Objectives

We sought to: 1) develop a prediction model for neurological outcome; and 2) evaluate the effect of early surgery (<24 hrs) on neurological recovery.

Methods

Patients with CCS (AIS C or D; LEMS–UEMS≥5) were identified from two prospective multi-center datasets. A prediction model was developed by multiple linear regression; the outcome was change in ASIA motor score (AMS) at 1-year. Covariates were chosen a priori: 1) age; 2) AMS; 3) AIS; 4) time to surgery (early [<24 hrs] vs. late [≥24 hrs]); and 5) time to surgery´AIS. Effect sizes were summarized by β coefficients. Internal validation was by bootstrapping.

Results

In total, 211 patients were eligible. β coefficients were significant for all variables in the model: age (-0.12, P=0.04); AMS (-0.71, P<0.01); AIS (9.69, P=0.01); time to surgery (12.67, P<0.01); time to surgery´AIS (-13.18, P<0.01). The mean R2 value across bootstraps was 0.66. In patients with AIS C injury, early surgery resulted in significantly improved motor recovery (marginal mean: 12.7, 95%CI 5.8–19.6); there was no difference in recovery with early surgery in patients with AIS D injury.

Conclusion

To our knowledge, this is the largest study to date to examine central cord syndrome. We found motor recovery after CCS may be predicted by age, AMS, AIS grade, and time to surgery. Early surgery improves recovery, particularly in patients with more severe injury.

9:05 - 9:15 Transpedicular vertebrectomy for thoracic spine metastasis

Tarush Rustagi, Hazem Mashally, Asad Akhter, **Ehud Mendel**, Ranjit Ganguly

Introduction

To study the feasibility, outcomes and complications of Transpedicular vertebrectomy (TPV) and reconstruction for metastatic lesions to the thoracic spine.

Objectives

From 2008-16, consecutive cases (single-surgeon) undergoing TPV for thoracic spine metastasis (T2 -12) were included. Demographic, surgical and clinical data was collected through chart review. MRI, CT, PET images were used to identify extent of disease, epidural spinal cord compression (ESCC), and degree of vertebral body collapse. Hall-Wellner confidence band was used for the survival curve.

Methods

96 patients were studies with a median age 60 years. Most patients 56 (58%) presented with mechanical pain. 29% cases had Lung metastasis. Single level TPV was performed in 73 patients (76%). Anterior reconstruction included PMMA in 78 patients (81.25%), and titanium cage in 18 patients (18.25%).

Results

Frankel grade improvement was seen in 16 cases (P=0.013). ESCC improved by a median of 5.9 mm (P<0.001). Kyphosis reduced by median of 7.5º (P<0.001). VAS improved by median of 7 (P<0.001). Total 59 deaths were observed. The median survival time was estimated to be 6 months (95% CI [5, 10]). Surgical outcome and complication rates are similar between the two construct types. Correction of kyphosis was seen to be slightly better with the use of PMMA. Overall 29.16% cases developed complications (11.4% major). Two cases developed neurological deficit following epidural hematoma requiring surgery. One case had instrumentation failure from cement migration, needing revision.

Conclusion

The result of our study shows good clinical and radiological outcomes for TPV for thoracic metastatic lesions.

9:15 - 9:35 Break

9:35-10:45 Peer Reviewed Abstract Session III: Tumor Science
Moderators: Nino Chiocca & Mitchel Berger

9:35 - 9:45 Meningioma Genomic Subgroup and Predicting Post-operative Patient Outcomes: Implications for Treatment and Follow-up

Daniel Duran, Amar Sheth, Koray Ozduman, Zeynep Erson-Omay, Chang Li, Julio Montejo, Evgeniya Tyrtova, Murat Gunel, Bulent Omay, Michel Kalamarides, Julien Boetto, Mark Youngblood, **Jennifer Moliterno**, Matthieu Peyre, Amy Zhao

Introduction

Previous studies have classified meningiomas into six molecular subgroups, including NF2, SMARCB1, KLF4, POLR2A, PI3K-activated and Hedgehog-activated. Each subgroup carries specific associations with clinical and molecular features, such as tumor location and histology.

Objectives

We sought to ascertain whether underlying genomic subgroup may provide prognostic value in meningioma management.

Methods

The genomic subgroup of over 500 meningiomas was determined based on targeted sequencing data and clinical annotations were retrospectively collected, including grade, recurrence, extent of resection (EOR), post-operative radiation, and follow-up. Statistical relationships were investigated between genomic subgroup and recurrence using Kaplan-Meier, Fisher’s exact tests, and Cox proportional hazards modeling, including stratification based on the aforementioned variables.

Results

During the first five post-operative years, meningiomas in the PI3K subgroup exhibited higher rates of early recurrence. PI3K activating mutations were found to be an independent predictor of recurrence free survival and irrespective of grade, Ki-67, and other clinical features. Conversely, recurrence was rare in KLF4, POLR2A, and SMARCB1 mutant tumors, and these tumors were typically associated with use of post-operative radiation. The longest average recurrence free survival was observed in POLR2A mutant meningiomas.

Conclusion

These results indicate divergence in meningioma patient outcomes based on underlying driver mutation and suggest patients with PI3K activating events may require closer surveillance. These cases, which often occur along the sphenoid wing and can encase critical neurovascular structures, may benefit from consideration of

radiation and emerging targeted medications. By contrast, for other subgroups which rarely recur, caution may be entertained before use of potentially morbid adjuvant therapies.

9:45 - 9:55 Oncolytic G207 Produces immunologic Signature Predicting Response to Therapy

Elaine Mardis, Naomi Barker, Kathleen Schieffer, Dragan Maric, Anthony Miller, G. Yancey Gillespie, Justin Roth, Josh Bernstock, **James Markert**, Nripesh Prasad, Kristen Leraas, Jianmei Leavenworth, Jennifer Coleman, Kevin Cassady, Gary Cutter, Bernard Roizman, Richard Whitley, Katherine Miller

Introduction

Our Phase I trials of experimental virotherapy for recurrent glioblastoma (GBM) have shown that inoculation with a conditionally replication-competent early generation oncolytic herpes simplex virus (oHSV), G207, is safe. However, while 17 of 37 subjects experienced objective clinical responses, the highly attenuated oHSV did not uniformly improve survival.

Objectives

We sought to identify predictors that would identify mechanisms contributing to survival and improve future trial design, by studying accrued samples.

Methods

We analyzed pre-treatment biopsy and post-G207-treatment tumor samples (collected D2-5 post injection) banked from the patients enrolled in the phase IB G207 trial. RNAseq and Nanostring transcriptome analysis with deconvolution using Cibersort was used to determine differences in immune response between samples. Multiplex fluorescent immunohistochemistry using immunocompatible primary antibodies and highly cross-absorbed secondary antibodies conjugated to spectrally-compatible dyes was also performed.

Results

The key findings from these analyses suggest that productive G207 infection and G207-induced changes in gene expression were predictive of oHSV therapeutic success in the G207-treated patients. RNAseq-based transcriptome analysis of these samples revealed that both the intrinsic IFN mediated antiviral response and adaptive immune functional response in patients correlated significantly with improved survival following G207 inoculation. Further, GBM tissue stained using multiplex fluorescent immunohistochemistry supported differences in the tumor microenvironments that were identified from RNAseq data analysis.

Conclusion

Our data indicate that both viral gene expression and the resulting intrinsic anti-viral and recruited adaptive response were critical for survival after G207 inoculation and predict survival with this early generation oHSV in patients with recurrent malignant glioma.

9:55-10:05 Evolution of Low Grade Gliomas During Malignant Transformation.

Joseph Costello, **Mitchel Berger**

Introduction

Newly diagnosed IDH mutant LGG may remain indolent for a decade after initial surgery, or may undergo malignant transformation (MT) to high grade glioma (HGG).

Objectives

We sought to elucidate the mechanisms and cause of malignant transformation as a critical step towards preventing MT and positively impacting overall survival for patients whose original diagnosis is LGG. In some cases this occurs at the first progression but in others there are multiple surgeries or other treatments before the diagnosis is made. Herein we discuss three distinct but related genetic mechanisms leading to malignant transformation, and one potential cause of malignant transformation.

Methods

Next generation sequencing was applied to primary and recurrent tumor pairs, along with multiple intratumoral samples to discover mutations and gene expression patterns during malignant transformation. Tumor evolution was elucidated using phylogenetic analysis.

Results

Phylogenetic analyses show that heterozygous mutations in IDH1 or IDH2 are the earliest genetic alteration in LGG and appear to be fully clonal. However, data from spatiotemporal tumor samples and in vitro and in vivo model systems showed deletion of the locus containing the IDH mutation during malignant progression. We also discovered Temozolomide induced hypermutation in LGG was strongly associated with malignant transformation.

Conclusion

We will discuss translational implications of the dynamic molecular, cellular, metabolic and clinical features of initially IDH1-mutant LGG as they undergo MT. The data also shows that Temozolomide induced hypermutation drives the outgrowth of tumor clones with increasingly malignant genotypes, and is associated with malignant transformation

10:05-10:15 Flies, worms and fish: What do these have to do with brain tumours?

James Rutka

Introduction

Although mammalian models have been commonly used to study cancer, the advent of molecular genetic manipulations in lower species has led to the development of a variety of highly reproducible and informative cancer models.

Objectives

To establish novel brain tumor models in lower species organisms; and to use high-throughput drug screening, and RNAi screening to identify novel drugs that are effective against these brain tumour models.

Methods

We used a let-60 (KRAS) and daf-18 (PTEN) mutant model of GBM in C. elegans in which the worms develop a highly invasive phenotype. We also developed a Drosophila Gal4/UAS transgenic line which overexpresses the fly homologues of human phosphoinositide-3 kinase (PI3K) and epidermal growth factor receptor (EGFR) in Drosophila.

Results

In the let-60 (KRAS) and daf-18 (PTEN) mutant model of GBM in C. elegans, we demonstrate enhancement of a multi-vulvar phenotype, indicative of a highly invasive alteration in cellular function that resmbles invasion in cancer cells. Our RNAi screen in C. elegans has uncovered several novel "hits" which are being explored. The developing pupae in the Drosophila model of GBM develop a highly proliferative and aggressive glial tumor resembling GBM. By treating these flies with anti-metabolic and novel chemotherapeutics, we show a reduction in tumor size and enhanced survival of the organism.

Conclusion

Just as science has advanced inordinately from taking advantage of the genetic manipulations in lower species, so it is hoped that these brain tumour models can be used to advance novel drug and therapeutics that would not be imaginable using conventional mammalian models to date.

10:15 - 10:25 Neurosurgical management of sinonasal malignancies involving the skullbase. A 25-year experience.

Franco DeMonte, Ehab Y Hanna, Gautam Mehta, Shaan M Raza

Introduction

Neurosurgical management of sinonasal malignancies extending to the skull base has a rich 6 decade long history. Early reports described high rates of morbidity and mortality. The most recently published large studies now date back over a decade.

Objectives

This longitudinal 25-year single institution study was undertaken to highlight how changes in patient demographics, practice patterns and outcomes have evolved. Over this time there has been a significant evolution in surgical instrumentation and techniques without a clear assessment of their impact on patient outcomes.

Methods

Patients with malignancies arising from the sinonasal cavities and extending to involve the skullbase who underwent surgical resection between 1993 and 2018 were included in this study. Only patients with at least a 6 month followup were included.

Results

191 patients met criteria for inclusion. Mean age was 51yrs and did not significantly change over time. Olfactory neuroblastoma was the most commonly encountered neoplasm. A trend of an increasing number of neuroendocrine tumors vs fewer SCCs and adenocarinomas was seen. More extensive/higher stage disease was seen over time. Surgical approaches evolved from open transcranial/transfacial to transcranial/endoscopically-assisted and endoscopic-only approaches. Median OS was 10.1 years and did not change over time. Complications were significantly reduced in those patients not undergoing lumbar spinal CSF drainage.

Conclusion

There has been an evolution over the past 25 years in the managment of patients with sinonasal malignancies extending to the skull base. Changes in surgical technique and management has lowered morbidity. Survival has remained unchanged despite treating patients with higher staged disease.

10:25-10:35 Opening of blood brain barrier in the hippocampus and entorhinal cortex in Alzheimer's disease with focused ultrasound

Jeff Carpenter, Marc Haut, **Ali Rezai**, Manish Ranjan, Rashi Mehta, Umer Najib

Introduction

There are no effective treatments for Alzheimer’s disease (AD). Animal studies have demonstrated that MR-guided focused ultrasound (FUS) reversibly opens the blood brain barrier (BBB)--reducing amyloid plaques, improving memory and allowing targeted drug delivery. A phase I safety study demonstrated opening of BBB in frontal lobe in five patients with AD.

Objectives

We report the initial results of a phase II study in AD evaluating if FUS treatment can safely and reversibly open the hippocampal BBB, and reduce amyloid plaques and cognitive decline.

Methods

The study was FDA and IRB approved. Three patients with early AD and positive amyloid PET each underwent three treatment sessions at two-week intervals with FUS (220 kHz ExAblate, Insightec) to the hippocampus/entorhinal cortex. Outcome assessments included MRI evaluating BBB opening, fMRI, adverse events, behavior/cognition, and amyloid PET.

Results

Three female participants (61-73 years) completed all treatments successfully. Three FUS treatments of the hippocampus/entorhinal cortex was performed in 3 seperate target regions (5X5X7 mm each) in the first, and four targets in the subsequent two subjects. There was no hemorrhage, edema, or treatment-related adverse effects. Immediate post FUS MRI with gadolinium revealed parenchymal contrast enhancement in

all target regions indicating BBB opening. Contrast enhancement was not present 24 hours after each treatment. Additional follow -up clinical, MRI, and PET outcomes will be available for presentation.

Conclusion

This is the first report demonstrating the safety, reversibility, reproducibility of multiple openings of BBB in the hippocampus/entorhinal cortex in AD with FUS. FUS provides a unique opportunity for targeted neurosurgical treatment approaches.

10:35 - 10:45 CAR T cell therapy for glioblastoma: Current observations and future directions

Donald O'Rourke

Introduction

Our work at the University of Pennsylvania involves the clinical application of chimeric antigen receptor T (CAR-T) cells for the treatment of glioblastoma (GBM). We identified antigen heterogeneity and adaptive immunosuppression in the tumor microenvironment (TME) as major challenges, based on our phase Ib study of a single peripheral infusion of CAR-T cells targeting EGFRvIII in recurrent GBM. We have defined strategies to overcome these challenges, representing the basis of a portfolio of new CAR-T clinical trials.

Objectives

First, we hypothesized that using a combination of CART-EGFRvIII cells and immune checkpoint blockade (ICB) would abrogate the TME response and improve clinical efficacy. Next, we have developed both cross-reactive scFvs in CAR constructs and multivalent CAR-T cells to address target heterogeneity and antigen escape.

Methods

Our single-arm, open-label, phase Ib trial is enrolling patients with newly diagnosed, MGMT-unmethylated, EGFRvIII+ GBM. Following maximal safe tumor resection, patients receive short course adjuvant radiation (40Gy), followed by three separate peripheral IV infusions of 2x108 CART-EGFRvIII cells and 200mg pembrolizumab.

Results

Kinetics of engraftment of EGFRvIII CAR-T cells was comparable in newly diagnosed GBM and recurrent GBM and resulted in disease stability. Combination of CAR-T cells with the PD-1 inhibitor pembrolizumab has not resulted in significant adverse events. Multivalent CARs, in parallel or tandem, resulted in activation by GBM cells expressing multiple antigens.

Conclusion

Combination of CAR-T cells and ICB presents a viable route to address TME immunosuppression while multivalent CAR constructs enable broader tumor targeting. Multivalent CAR-T cells with ICBs will likely improve clinical efficacy in GBM.

10:50-11:50 Peer Reviewed Abstract Session 4: Vascular Science
Moderators: Elad Levy & Robert Spetzler

10:50 - 11:00 Functional Connectivity Deficits After Subarachnoid Hemorrhage

Deepti Diwan, Ananth Vellimana, Annie Bice, Lindsey Brier, Joseph Culver, **Gregory Zipfel**, Julian Clarke

Introduction

Previously, we showed that hypoxic conditioning is a novel therapy against two components of SAH-induced delayed cerebral ischemia (DCI), and that this protection is SIRT1-mediated. Functional connectivity (FC) refers to correlation analysis across cortical regions and is commonly used as a readout of coordinate neural activity. FC can be measured via Optical Intrinsic Signal (OIS) imaging, which measures correlations in

vascular reactivity via quantitation of fluctuations in oxy- and deoxy-hemoglobin. The impact of experimental SAH and conditioning on FC has yet to be examined.

Objectives

This study examined three questions: 1) Does experimental SAH induce FC deficits; 2) Does hypoxic conditioning provide protection against these FC deficits and is this protection SIRT1-mediated; and 3) does treatment with the SIRT1 activator, resveratrol, mimic the protective effect of hypoxic conditioning against these FC deficits?

Methods

Cranial windows were adhered on C57BL/6 mice. Mice underwent sham or SAH surgery. Mice were then treated with hypoxic conditioning (with or without EX527, a SIRT1-inhibitor) or resveratrol beginning 3hr after surgery. Mice were serially imaged post-surgery.

Results

We found that experimental SAH induces global and network-specific deficits in FC by day 3, corresponding with the time of DCI in mice; and that hypoxic conditioning provides SIRT1-mediated protection against these SAH-induced FC deficits (see Figure). We also found that the SIRT1 activator, resveratrol, mimics the protective effect of hypoxic conditioning on SAH-induced FC deficits.

Conclusion

OIS imaging is a useful technique for identifying FC deficits following experimental SAH. SIRT1 targeted therapies attenuate FC deficits observed post-SAH and may be an important step in treatment of DCI after SAH.

11:00 - 11:10 Microbiome Signatures of Cavernous Angioma

Le Shen, Amy Akers, **Sean Polster**, Issam Awad, Kimberly Yan, Julian Carrion-Penagos, Helen Kim, Agnieszka Stadnik, Jack Gilbert, Connie Lee, Anukriti Sharma, Ying Cao, Romuald Girard, Myranda Robinson, Leslie Morrison, Seán Lyne, Atif Zafar, Mark Kahn, Patricia Mericko, Alan Tang

Introduction

Cavernous angiomas (CA) can result in hemorrhage and/or seizure. The disease course is variable which may be affected by immune and inflammatory processes. Mouse studies have linked CA to the microbiome, but its clinical relevance has not been defined.

Objectives

Here we investigate the composition of the microbiome of CA patients and its relationship to clinical disease.

Methods

Fecal samples from 123 CA patients, across four centers, were assayed using metagenomic 16S rRNA and shotgun sequencing. Following taxonomic classification microbiome composition was compared with those of a non-CA population (n=263), or between subgroups of CA patients based on clinical characteristics. Univariate and random forest identified species were assembled to compare with plasma biomarkers of angiogenic and inflammatory cytokines.

Results

Analyses of microbiome composition identified groups and networks of bacterial species that identify CA from non-CA patients. Four species differentiate CA from non-CA by receiver operating characteristic classification [area under the curve (AUC)=0.875, specificity=0.890, sensitivity=0.815]. Within CA cohorts, a combination of microbiome and a plasma biomarker improved our ability to differentiate patients with unique CA characteristics; sporadic vs. familial (AUC=0.71), aggressive vs. non-aggressive (AUC=0.90) and those with a symptomatic hemorrhage (CASH) in the last year (AUC=0.86).

Conclusion

This data is the first to show that CA patients have a distinct microbiome that is strongly associated with CA disease and CA behavior. This study supports further investigation into the mechanistic link between CA

disease and the microbiome for a better understanding of the brain-gut axis and as a potential biomarker of disease behavior.

11:10 - 11:20 The New Generation Hydrogel Endovascular Aneurysm Treatment Trial (HEAT): Final Results

Bernard Bendok, Salah Aoun, Jason Kniss, Jennifer Ward, Karl Abi-Aad, Tarek El Ahmadieh, Samer G. Zammar, Rudy Rahme, Najib El Tecle, Mary Kwasny, Rami James Aoun

Introduction
Aneurysm recurrence after coiling has been associated with (re)hemorrhage and a greater need for follow-up. The second-generation HydroCoil Embolic System (HES) consists of a platinum core with integrated hydrogel and was developed to reduce recurrence through enhancing packing density and healing within the aneurysm.
Objectives
To compare the imaging and clinical outcomes of the second-generation HES to bare platinum coils in a long-term study of 600 patients.
Methods
HEAT is a randomized, controlled clinical trial that enrolled subjects with ruptured or unruptured intracranial small-to-medium aneurysms amenable to endovascular coiling. Subjects were randomized in a 1:1 fashion at 46 participating sites. The primary endpoint was aneurysm recurrence using the Raymond-Roy scale at final follow-up. Secondary endpoints included minor and major recurrence, packing density, adverse events related to the procedure and/or device, mortality, initial complete occlusion, aneurysm retreatment, hemorrhage from target aneurysm during follow-up, aneurysm occlusion stability, and clinical outcome at final follow-up.
Results
A total of 600 patients were randomized including 28% with ruptured aneurysms. Recurrence occurred in 11 (4.4%) subjects in the HES arm and 44 (15.4%) subjects in the BPC arm (p=0.002). While the initial occlusion rate was higher with BPC, the packing density and both major and minor recurrence rates were in favor of HES. Secondary endpoints including adverse events, retreatment, hemorrhage, mortality and clinical outcome did not differ at follow-up.
Conclusion
Coiling of 3-14 mm ruptured and unruptured aneurysms with second-generation HES resulted in significantly less recurrence when compared to BPC, without increased harm.

11:20 - 11:30 The R2eD AVM score: a novel predictive tool for arteriovenous malformation presentation with hemorrhage

Wuyang Yang, Cameron McDougall, Jason Liew, Rafael Tamargo, Risheng Xu, Justin Caplan, **Judy Huang**, James Feghali

Introduction
The management of unruptured brain arteriovenous malformations(AVMs) remains unclear.
Objectives
We developed a predictive tool to determine risk factors predictive of AVM hemorrhage on presentation.
Methods
789 AVM patients presenting between 1990 and 2017 were analyzed. A hold-out method of model building and validation split the data randomly in half into training and validation datasets. Factors significant at the univariable level in the training dataset were utilized to construct a model based on multivariable logistic regression. Model performance was assessed using receiver operating curves(ROC) on the training, validation,

and complete datasets. The model predictors and the complete dataset were used to derive a formula for risk prediction and scoring system where every risk factor was worth 1 point except race, worth 2 points (total score varies from 0 to 6), comprising acronym R2eD AVM.
Results
Among 755 patients, 272(36%) presented with hemorrhage. From the training dataset, a model was derived containing the following: non-white race (odds ratio [OR]=1.8,P=0.02), small nidus size (OR=1.47,P=0.14), deep location (OR=2.3,P<0.01), single arterial feeder (OR=2.24,P<0.01), and exclusive deep venous drainage (OR=2.07,P=0.02). Area under the curve from ROC analysis was 0.702, 0.698, and 0.685 for training, validation, and complete datasets, respectively. In the study population, the predicted probability of hemorrhagic presentation increased in a stepwise manner from 16% for patients with no risk factors (score 0) to 78% for patients having all the risk factors (score 6).
Conclusion
A score ranging from 0-6, known by acronym R2eD AVM, can be used as predictive tool that supplements clinical judgement and assists in patient counselling.

11:30-11:40 Cerebral Aneurysm Formation and Rupture: Role of Nrf2 Signaling

Christopher Carr, Crissey Pascale, Peter Amenta, Alejandra Martinez, **Aaron Dumont**

Introduction
Oxidative stress and chronic inflammation have been implicated in cerebral aneurysm (CA) formation and rupture. Nrf2 is an endogenous anti-oxidant/anti-inflammatory mediator that normally promotes vascular homeostasis.
Objectives
The objective of this study is to evaluate the role of Nrf2 signaling in CA formation and rupture and to specifically examine the therapeutic potential of the Nrf2 activator, dimethyl fumarate (DMF), in preventing cerebral vascular smooth muscle cell (VSMC) damage and CA formation and rupture.
Methods
The therapeutic potential of DMF was evaluated in vitro and in vivo. Cultured cerebral VSMC were treated with TNF-α and/or DMF . Gene and protein expression for Nrf2, cytokines and VSMC markers were then evaluated using real-time RT-PCR and a Bio-Plex Immunoassay. Mitochondrial function was assessed using the Seahorse analyzer to evaluate oxygen consumption rate. Aneurysms were induced in C57BL/6 mice using the elastase model. The mice were then treated with either DMF at 100mg/kg/day or vehicle for two weeks. Subsequently, the circles of Willis were harvested for gene expression analysis and mass spectrometry.
Results
DMF treatment protected VSMCs from TNF-α induced inflammation as demonstrated by its downregulation of cytokines and upregulation of Nrf2 and smooth muscle cell markers. Furthermore, DMF appeared to mitigate TNF-α induced oxidative stress and preserved mitochondrial dysfunction. In mice, DMF treatment increased vascular Nrf2 expression and significantly decreased the incidence of CA formation and rupture through suppression of inflammation and oxidative stress while preserving mitochondrial function.
Conclusion
Nrf2 activation with DMF represents a novel medical therapy to prevent CA formation and rupture through suppression of inflammation/oxidative stress and preservation of mitochondrial function.

11:40 - 11:50 Early Gene Deletion Generates a High-Fidelity Transgenic Mouse Model of Familial Brain Arteriovenous Malformations

SP Oh, **Michael Lawton**

Introduction

The pathogenesis of BAVMs has been explored in animal models using genetic insights from patients with hereditary hemorrhagic telangiectasia (HHT) and the technique of regional conditional gene deletion. These experimental lesions lack the anatomical and hemodynamic hallmarks observed in human BAVMs, likely because they are induced in fully developed mice, long after fetal development when abnormal vasculogenesis is thought to trigger BAVM formation. Here, we present a mouse model for BAVM that, for the first time, replicates human BAVMs anatomically and hemodynamically by deleting HHT genes during embryonic gestation.

Methods

We used Tagln (SM22a)-Cre:Alk12f/2f and Tagln-Cre:Eng2f/2f mice that were previously shown to develop BAVMs. Magnetic resonance imaging with GEFC (gradient echo with flow compensation) was acquired serially from the mutant and control mice starting at 1-2 months of age up to 12 months using Bruker 7T MR spectrometer.

Results

The survival rate of Tagln-Cre:Alk12f/2f mice at 1 and 3 months of age was 90% and 70% respectively. In total, 41 mice were subjected to MR imaging: 5 control, 29 Alk1-mutants, and 6 Eng-mutants. Obvious lesions of varying sizes and locations in the brain were detected in 95% (33/35) of mutant brains but none of control brains. While MR angiography visualized only arteries in control brains, BAVMs including feeding arteries, draining veins, and varying sizes and shapes of nidus were detected in 54% of mutants (19 of 35). Repeated MRA images in 11 mutant mice in a course of 12 months revealed that most BAVMs detected in the first scan remained stable, but some changed dynamically.

Conclusion

This study demonstrates the formation of BAVMs in transgenic mice with the morphological, anatomical, and hemodynamic features of BAVMs seen clinically in humans, based on MR imaging, angiography, and histology. Timing of ALK1 and ENG deletion is critical in generating clinically relevant pathology. This model provides an experimental system for studying BAVM rupture and evaluating drugs that may induce regression of BAVMs.

11:50 - 12:00 Break

12:00 - 12:50 Special Lecture I

Moderator: Alex Golby / James Rutka

The Rhetoric of Medicine: Lessons on Professionalism From Ancient Greece

Nate Selden/Nigel Nicholson

7:30 – 7:35 WELCOME & REMARKS

Michael McDermott (Scientific Program Chair) & **Alex Olivi** (Local Arrangements Chair)

7:35-8:35 Peer Reviewed Abstract Session V: Vascular

Moderators: Michael Lawton & E. Sander Connolly

7:35 – 7:45 Deletions in CWH43 Cause Sporadic Idiopathic Normal Pressure Hydrocephalus

Mark Johnson

Introduction

Idiopathic normal pressure hydrocephalus (iNPH) is a neurological disorder of aging that is characterized by enlarged cerebral ventricles, gait difficulty, incontinence and dementia. The cause and pathophysiology of sporadic iNPH are unknown.

Objectives

The goal of this study was to identify genetic abnormalities associated with sporadic iNPH.

Methods

We performed whole-exome sequencing of DNA obtained from 53 unrelated iNPH patients in 3 independent cohorts. Single nucleotide variations that were statistically overrepresented among iNPH patients, present in at least two of the three cohorts, and predicted to adversely affect protein function were identified. Deletions affecting the most frequently altered gene were studied further using genetically engineered mice and human cell lines.

Results

A heterozygous deletion in CWH43 was observed in four iNPH patients and was enriched 6.6 fold when compared to the general population (P<0.0002, X2 Test). A second heterozygous CWH43 deletion was identified in four additional patients and was enriched 2.7 fold (P<0.0406, X2 Test). We show that Cwh43 regulates the membrane localization of GPI-anchored proteins in mammalian cells, and both of the iNPH-associated CWH43 deletions disrupt this function. Cwh43 expression is high in choroid plexus and ependymal cells. Genetically-engineered mice harboring CWH43 deletions displayed enlarged ventricles, gait and balance abnormalities, decreased numbers of ependymal cilia and aberrant localization of GPI-anchored proteins in ventricular epithelial cells.

Conclusion

Approximately 15% of patients with sporadic iNPH harbor deletions in CWH43. Mice harboring CWH43 deletions develop an iNPH-like syndrome. Our findings provide new mechanistic insights into iNPH and demonstrate that it represents a distinct disease entity.

7:45-7:55 NEWTON-2: Randomized, Double-blind, Placebo-controlled study of EG 1962 in Aneurysmal Subarachnoid Hemorrhage

E. Francois Aldrich, Daniel Haenggi, Stephan Mayer, Michael Diringer, Newton Investigators, Nima Etminan, Andrew Carlson, George Wong, **R. Loch Macdonald**, Erich Schmutzhard

Introduction

EG-1962 is a sustained release nimodipine formulation administered via an external ventricular drain (EVD) to patients with aneurysmal subarachnoid hemorrhage (aSAH). A randomized, open-label, phase 1/2a, dose-escalation study found EG-1962 was safe and well-tolerated.

Objectives

To evaluate efficacy and safety of a single intraventricular 600 mg dose of EG-1962 in patients with aSAH, compared to standard of care nimodipine in a randomized, double-blind, placebo-controlled phase 3 study.

Methods

Subjects were WFNS grades 2-4, modified Fisher grades 2-4 and had an EVD. EG-1962 was administered within 48 hours of aSAH. The primary endpoint was favorable outcome at 90 days (extended Glasgow outcome scale [eGOS] 6-8).

Results

The study was halted after planned interim analysis (282 subjects randomized) found the study was unlikely to achieve its primary endpoint. After 90 day follow-up, the proportion with favorable outcome on the eGOS was 46% (64/138) for EG-1962 and 43% (62/144) for placebo group (p=0.74). Consistent with its mechanism of action, EG-1962 significantly reduced vasospasm (50% [69/138] EG-1962 versus 63% [91/144], p=0.025), rescue therapy (27% [37/138] versus 35% [50/144]) and hypotension (7% [9/138] versus 10% [14/144]). Mortality also was lower (7% [10/138] versus 10% [15/144]). Prespecified subgroup analysis suggested efficacy in WFNS 3-4 subjects (46% [32/69] EG-1962 versus 32% [24/75] placebo, p=0.063). No safety concerns or imbalance in adverse events were identified.

Conclusion

This study found no significant improvement in favorable outcome for EG-1962 compared to standard of care in the overall group. Favorable outcome was higher in the prespecified WFNS 3-4 subgroup. The safety profile was acceptable.

7:55-8:05 When Flow Diversion Fails: Predictive Factors of Incomplete Aneurysm Occlusion after Pipeline Embolization

Christopher Ogilvy, Peter Kan, Paul Foreman, Sricharan Gopakumar, Clemens Schirmer, Christoph Griessenauer, Santiago Gomez-Paz, Abhi Jain, Mohamed Salem, Georgios Maragkos, Ajith Thomas, Luis Ascanio, Alejandro Enriquez-Marulanda

Introduction

Flow diversion with the Pipeline Embolization Device (PED) has become an alternative endovascular treatment for select intracranial aneurysms. To date, high rates of aneurysmal occlusion have been reported with no recanalizations after aneurysm obliteration.

Objective

To identify factors predictive of incomplete aneurysmal occlusion on last angiographic follow-up after PED treatment.

Methods

A multi-center retrospective cohort analysis was conducted on consecutive patients treated with PED at 3 academic institutions in the United States. Patients with angiographic follow-up assessing the degree of aneurysm occlusion were selected to identify the factors associated with incomplete occlusion.

Results

Among all 3 participating institutions we identified a total of 523 PED placement procedures. Three hundred and ninety-five of these (75.5%) had radiographic follow-up and were included in this analysis (age median 58 years; female-to-male ratio 4.4:1). Complete occlusion (Raymond-Roy class I) was noted in 68.6% of cases, while incomplete occlusion (Raymond-Roy class II or III) at last follow-up was identified in 31.4% after a median of 6 months. After accounting for factor collinearity and confounding, multivariate analysis identified older age (≥70 years; OR=3.07, 95% CI 1.77-5.32, P<0.001), higher maximal diameter (≥15 mm;

OR=3.33, CI 1.65-6.71, P=0.001) and fusiform morphology (OR=3.04, CI 1.56-7.42, P=0.002) to be independently associated with higher rates of incomplete occlusion on last follow-up.

Conclusion

In this study we demonstrate that age, aneurysm diameter and fusiform morphology are associated with incomplete aneurysm occlusion after PED placement. Such predictive factors can be utilized to guide individualized treatment selection and counseling in cerebrovascular neurosurgical patients. Furthermore, these results provide a clinical background for research on the biologic factors affecting endothelialization of the PED.

8:05-8:15 Transradial Cerebral Angiography: A Safer Alternative

Andrew Ducruet, **Felipe Albuquerque**, Vance Fredrickson, Joshua Catapano

Introduction

Neurointerventionalists have not widely embraced transradial access as a conduit for cerebrovascular angiography.

Objectives

We sought to analyze the Barrow Neurological Institute experience with the transradial approach specifically assessing complications occurring as a result of distal (anatomic snuffbox) and proximal (standard) radial artery catheterization.

Methods

We reviewed all cerebral angiograms performed at our institution from October 1, 2018 to June 1, 2019, when our service adopted transradial catheterization as an option to femoral artery sheath placement. We specifically assessed type of procedure (diagnostic versus neurointerventional), type of transradial approach (snuffbox versus standard), laterality of puncture, and complications.

Results

From a total of 1104 diagnostic and neurointerventional cerebral angiograms performed during this 8-month period, 140 were completed through a transradial approach. Of these, 83 were done through proximal catheterization and 57 via the snuffbox. Snuffbox catheterization was performed at greater frequency during the later weeks of the study after proficiency had been achieved with standard catheterization. Ninety-five of these procedures involved diagnostic angiography while the remaining 45 were neurointerventions. The majority of the procedures were performed via the right radial artery (133 or 95% of cases). Only 1 permanent complication (0.71%), a small thromboembolic cerebrovascular accident, and 3 minor complications (2.14%) occurred.

Conclusion

Transradial catheterization for both diagnostic and neurointerventional angiography is exceptionally safe. Understanding the specific clinical scenarios in which transradial access is contraindicated or likely to fail is essential to ensuring the safety of this procedure. Both the standard and snuffbox approaches had similar safety profiles.

8:15-8:25 Somatic mutations in cerebral aneurysms

Geoffrey Colby, Mike Niemela, Alan Boulos, Scott Weiss, Edison Valle-Giler, Wendy Huang, H. Hunt Batjer, Arthur Day, Lawrence Dickinson, Xiangen Shi, Anthony Wang, Spiros Blackburn, Bradley Gross, Daniel Barrow, Pui Man Rosalind Lai, **Rose Du**, Kai Frerichs, Nirav Patel, Edie Zusman, Sarajune Dagen, Edward Chang, Babu Welch, G. Rees Cosgrove, Steven Ojemann, Mohammad Ali Aziz-Sultan, P. Roc Chen, Carlos David

Introduction
Despite recent genome-wide association studies, the pathogenesis of cerebral aneurysms remains unclear.

Objectives
While somatic mutations have been well-studied in cancer, their roles in other complex traits are much less understood. Our goal is to identify somatic variants that may contribute to the formation of cerebral aneurysms.
Methods
We performed whole exome sequencing on aneurysm tissues and matched peripheral blood obtained from 30 patients. Differential expression analysis was additionally performed on aneurysm tissue and control intracerebral arteries.
Results
284 non-synonymous somatic mutations within exon regions of 263 genes (median 7 per aneurysm tissue, range 1-29) were found with the highest representation of single-nucleotide variants predicted as missense mutations. Somatic variants that involve supervillin (SVIL) and its regulation were found in 17% of aneurysm tissues. SVIL was differentially down-regulated in aneurysm tissues of patients with mutations in SVILcompared to normal controls. Pathway enrichment analysis demonstrated that mutations in the vascular endothelial growth factor (VEGF) signaling pathway (FDR=0.011), chromatin modifying enzymes (FDR=9.33x10-3), and integrin signaling pathway (FDR=0.025), were found in 60% (N=18) of patients.
Conclusion
We propose that these somatic changes in aneurysm tissue may explain the heterogeneity of genetic inheritance and environmental influences on the development of this disease.

8:25-8:35 Intracranial Aneurysms: Does Size Really Matter?

Philip Stieg, Kashif Majeed, Srikanth Boddu

Introduction
To stratify the risk of rupture from intracranial aneurysms, size remains the primary criteria as proposed by two ISUIA trials. Observation for ≤7mm aneurysms which have low propensity to rupture has been proposed. Given the severe outcome after subarachnoid hemorrhage, the application of these recommendations has been contested.
Objectives
To retrospectively assess whether size correlates with aneurysmal rupture, and to analyze outcomes of endovascular and microsurgical procedures.
Methods
Aneurysm cases between 2016-2019 were reviewed. Age, gender, comorbidities, rupture and unruptured status, modes of treatment (clipping, coiling and observation) and their outcomes were noted. The descriptive statistics, and cross-tabulations were generated. Regression analysis was done to correlate size with aneurysmal rupture.
Results
Of the 633 aneurysms, 109 had ruptured. In the five size groups: 0-6mm, 7-12mm, 13-18mm, 18-24mm and giant, the proportion of ruptured aneurysms was 63.3%, 30.2%, 1.8%, 6.4 and 0.9% respectively.
Ruptured aneurysms were 0.0%, 16.5%, 50.4%, and 30.2% in age groups 0-18, 19-44, 45-64 and ≥65, respectively.
The majority (400) were managed endovascularly. 87 (14%) underwent clipping, 26 of those were ruptured and 61, unruptured. The mean modified Rankin score for clipped aneurysms was zero. One inpatient death, and single brainstem stroke was noted in the coiled group. 142 were followed. The mean modified Raymond-

Roy classification for treated aneurysms was 1.1, with 264 completely occluded; 31 had a score of 2, and 33, of score 3.

Conclusion
Small aneurysms ruptured more frequently than reported previously. Surgical clipping was superior in outcome. Further studies to better understand unique aneurysmal characteristics to predict the risk of rupture are needed.

8:35-9:15 Peer Reviewed Abstract Session VI: Tumor
Moderators: Henry Brem / Don O'Rourke

8:35-8:40 Long-Term Outcomes in the Treatment of Pediatric Skull Base Chordomas

Eric Wang, Michael McDowell, **Paul Gardner**, Carl Snyderman, Nathan Zwagerman, Elizabeth Tyler-Kabara

Introduction
Pediatric skull base chordoma is a rare entity that is traditionally considered to display aggressive behavior and a tendency to recur. However, there is an absence of literature examining outcomes using the endoscopic endonasal approach.
Objectives
Assess the outcomes of pediatric skull base chordoma patients undergoing endonasal resection.
Methods
We retrospectively reviewed all patients presenting up to age 18 with skull base chordomas to the University of Pittsburgh Medical Center from 2004 to 2018.
Results
Eighteen patients met criteria. The most common presenting complaints were diplopia (n = 7), headache (n = 5), and swallowing difficulty (n = 4). Three cases were incidentally discovered. Eleven patients underwent endoscopic endonasal approach (EEA) alone, five patients had combined EEA with open far lateral or extreme lateral approaches, and two patients had two-stage EEA procedures. Thirteen patients had gross total resection based on intraoperative impression and post-operative imaging and five patients had near total resection (>95%). Five patients developed cerebrospinal fluid leaks requiring re-operation, one patient developed a permanent abducens palsy, one patient suffered an internal carotid injury that required carotid sacrifice and resulted in a Horner’s syndrome, one patient developed an epidural hematoma, and one patient developed a subdural empyema. Three (16.7%) patients developed tumor progression during follow-up. The mean radiographic follow up was 57 months.
Conclusion
Pediatric skull base chordoma, when managed aggressively at a specialized center with a goal of gross total resection, may have a better outcome than traditionally believed. Elevated Ki-67 rates may predict poor outcome.

8:40-8:50 MRI Perfusion Radiomic Machine Learning Identifies Pseudoprogression in Glioblastoma – A Multicenter Study

Samuel Bergamaschi, Nabil Elshafeey, Ahmed Hassan, Meng Law, **Pascal Zinn,** Aikaterini Kotrotsou, Nancy Elshafei, Jason Huse, Fanny Moron, Anand Agarwa, Gregory Fuller, Sara Ahmed, Rivka Colen, Kamel Salek, Srishti Abrol, Jay Acharya

Introduction

Multi-modal Glioblastoma therapy with radiation and Temozolomide, including immunotherapy and clinical trials is common. Advanced glioblastoma treatment may complicate MR image assessment for therapy response. Therapy related inflammatory changes typically stabilize or subside without further treatment, but they are often difficult to distinguish from progressive disease (PD). This PD-mimicking phenomenon is called pseudoprogression (PsP). Early discrimination of PsP from PD is a clinical challenge that currently requires biopsy for definite diagnosis.

Objectives

To address this gap in assessment tool availability our objective was to create a radiomic texture image analysis pipeline for perfusion MR images and to leverage machine learning algorithms to diagnose PsP with high accuracy.

Methods

A total of 98 patients from 3 institutions with histopathologically confirmed PsP and PD and available dynamic susceptibility contrast and dynamic contrast–enhanced perfusion MRI images were included. A classifier using radiomic features obtained from both Ktrans and rCBV maps coupled with support vector machines was derived and tested in the primary data set and in a separate prospective patient cohort.

Results

MRI perfusion radiomic texture analysis demonstrates an accuracy of 90.82% (area under the curve (AUC)=89.10%, sensitivity=91.36%, specificity=88.24%, p=0.017) in differentiating between PsP and PD. The diagnostic performances of the models built using radiomic features from Ktrans and rCBV separately were equally high (Ktrans: AUC=94%, 69 p=0.012; rCBV: AUC=89.8%, p=0.004).

Conclusion

The MR perfusion based radiomic model demonstrates high accuracy, sensitivity and specificity in discriminating PsP from PD, thus providing a tool for noninvasive identification of PsP versus PD at the time of clinical question.

8:50-9:00 The evolution of epilepsy surgery for children: lessons from tuberous sclerosis complex over 20 years

Howard Weiner

Introduction

Pediatric epilepsy surgery has grown significantly over the last 20 years, due to both philosophical and technological advances. Because of the multiple epileptogenic brain lesions in Tuberous Sclerosis Complex (TSC), targeted epilepsy surgery was only considered in the small subset of children with focal epilepsy, with the remainder offered palliation. We previously treated 120 TSC patients with staged craniotomy and seizure focus resection.

Objectives

Given the natural history of TSC, and the evolving concept of palliative surgery, our objective was to develop a novel comprehensive treatment paradigm, which incorporates both traditional resective and minimally invasive strategies.

Methods

Over 36 months, we treated 37 TSC children with refractory epilepsy, who had VEEG, MRI, CT, MEG, PET, and were referred for either resective surgery or stereotactic laser ablation (SLA). Most patients underwent an initial phase of stereo EEG (SEEG) monitoring, some had subdural grid electrodes, and two had no intracranial EEG. Outcome was considered improved with at least a 50% reduction of the targeted seizure type.

Results

12 children had prior epilepsy surgery elsewhere. 21 had SLA, 14 resection, one SLA after failed resection, and one resection after failed SLA. 17 of the 22 SLA and 11 of 15 resection patients were improved. Complications included one abscess.

Conclusion

Advances over 20 years reveal that more TSC patients are candidates for targeted surgery, and have changed our notion of palliation. Children can improve after surgery, despite not being completely seizure free. A new, less invasive approach is possible for select children with TSC and has facilitated a new, iterative epilepsy surgery paradigm.

9:00-9:10 Stimulated Raman Histology for Rapid Neurosurgical Intraoperative Histology: A Prospective Series

Ricardo Komotar, Michael Ivan , Ashish Shah, Long Di, Alexa Semonche, **Allan Levi**, Daniel Eichberg, Sakir Gultekin, Christopher Sarkiss

Introduction

Within neurosurgical oncology, intraoperative frozen section diagnosis remains a mainstay of surgical practices, permitting accurate diagnosis and potentially influencing intraoperative decision making. However, delays in frozen section diagnosis can prolong surgical times and potentially adversely affect the extent of resection. Stimulated Raman Histology (SRH) allows for non-invasive, fast, high resolution acquisition of structural information through spectral image generation. Here we investigate the utility of a novel system, SRH, to prospectively identify pathological tissue by creating a simulated “frozen section” potentially facilitating a rapid diagnosis.

Objectives

To assess frozen/permanent histopathology diagnostic time and accuracy to novel Raman Stimulated Histology

Methods

We prospectively conducted a single center cohort study comparing time from specimen collection to diagnosis for stimulated intraoperative pathology consult with SRH, with actual intraoperative frozen section diagnosis. Additionally, diagnostic accuracy was determined by concordance of SRH simulated intraoperative pathology consult with a blinded board-certified neuropathologist, with frozen section and permanent section results. Primary outcome was time from specimen collection to diagnosis for stimulated intraoperative pathology consult with SRH and for actual intraoperative frozen section diagnosis. Secondary outcome was Cohen’s Kappa coefficient (κ) for concordance between SRH simulated intraoperative pathology consult with a blinded board-certified neuropathologist, with actual frozen section and permanent section results.

Results

Of the 82 patients, average age was 60.2 years and 50% were female (n=40). Time to diagnosis was 10.14 minutes for SRH and 40.65 minutes for frozen section (p<0.0001). Diagnostic correlation was 91.5% for SRH and permanent section and 91.5% for frozen and permanent section. Correlation between SIRSM and standard histopathological permanent section was greater than 95%.

Conclusion

SRH is a promising histological adjunct for rapid intraoperative pathologic consultation, and can be successfully implemented in the workflow of a neurosurgery operating room to shorten operative times.

9:10 – 9:20: Role of Visual Cortex in Essential Tremor

Jean Régis, Tatiana Witjas, Axelle Cretol, Eric Guedj and Constantin Tuleasca.

Introduction/Objective
In order to study predictors of outcome after Gamma Knife Radiosurgery (GKS) in essential tremor (ET), and to better understand the physiology of tremor, we studied clinical and imaging data pre and postoperatively.
Methods
Between January 2004 & November 2018, 626 patients had GKS at our center. In this prospective cohort the tremor was an essential tremor (ET) in 432 patients. GKS was performed on the left VIM in 81% of the patients. The mean age was 73 years (min 31- max 93). Tremor, neuropsychological exam, speech, gait and balance were all assessed before and 1 year after. We performed modern neuroimaging techniques for the study of the radiobiology of Vim GKS. We used both structural [e.g. T1 weighted (T1-w), voxel-based morphometry (VBM)] and functional resting-state functional MRI (rs-fMRI).
Results
The mean follow up is 18 months. The mean delay of action of radiosurgery was 4,5 months. The mean disability was before GKS of 30.2/75 and at the last FU of 8.9/75 for a mean improvement of 70.5%. The mean amplitude of the hand tremor on the treated side before GKS was 18.7 and at the last FU, 6.6 for a mean improvement of 65%. The mean functional impact before GKS was 7.7/28 and at the last FU, 2.5/28 for a mean improvement of 68%. An hyper-response to radiosurgery associated neurological side effects (proprioceptive ataxia, dysarthria, hemiparesis) was observed in 7% of the patients and led to rehabilitation. Despite a standard radiosurgical procedure, there is a variability in the clinical effect, with a similar efficacy rate as compared to standard deep-brain stimulation, the reference technique.
The most relevant and novel contribution was the presence of a visually-sensitive structural and functional network, involved in tremor generation and further arrest after Vim GKR. The patients with this network benefited more from GKS. We modified the term "cerebello-thalamo-cortical" into the "cerebello-thalamo-*visuo*-motor" network, as a step forward in the understanding of essential tremor's pathophysiology. Two structures were proposed as main calibrators of this network: the cerebellum (as the most probable) versus the thalamus itself. Moreover, a more classical basal ganglia network, as well as a cerebellar, interconnected with the motor and visual one, were reported. Other longitudinal changes involved dorsal attention, insular or supplementary motor area circuitries, shedding new light on tremor arrest after surgery. Particular phenotypes of ET, including patients with head tremor, were analyzed.
Conclusion
We found a high safety to efficacy ratio of GKS in this population of aged and fragile patients. The ET network classically involves mainly the dentate nucleus, the ventrolateral thalamus and the primary motor cortex. However, our data from structural & functional connectivity, PET and VBM are showing the role of visual cortical areas as predictors of response to radiosurgery. These areas are demonstrated additionally to be modified by radiosurgery, in a was different in responders and non-responders. We provide a new network perspective to this disorder.

9:15-9:30 Break

9:30-10:30 Peer Reviewed Abstract Session VII: Spine
Moderators: Kevin Foley & Praveen Mummaneni

9:30-9:40 Early Results from the CSM-S RCT: Quality of Life, Cost, and Complications

Robert Heary, Todd Albert, Paul Arnold, Michael Fehlings, Jill Curran, **Zoher Ghogawala**, Adam Kanter, Erica Bisson, Edward Benzel, Robert Whitmore, John Heller, Frederick Barker, Praveen Mummaneni, Michael Steinmetz, Subu Magge, K Daniel Riew, Marjorie Wang

Introduction
The optimal surgical approach (ventral vs. dorsal) for treating CSM is not known.
Objectives
To compare the effectiveness of three major surgical treatments for CSM.
Methods
A prospective RCT was conducted on patients aged 45-80 years with multi-level CSM. Patients were randomized to ventral or dorsal surgery (2:3 randomization) from 15 sites from 2014-2018. Dorsal surgical approach (dorsal fusion or laminoplasty) was at the discretion of surgeon and patient. Outcome assessments (SF-36, NDI, mJOA, and EQ-5D) along with patient work status were obtained pre-operatively, 3 months, 6 months, and 1 year post-operatively. Complications were assessed by an independent study coordinator.
Results
Fifteen sites randomized 163 patients. 63 (38.7%) were randomized to ventral surgery and 100 (61.3%) to dorsal. Average age was 62.2 years (49% male). Baseline characteristics were comparable. Crossover rate was 3%. Follow-up was 95% (155 patients) at 1 year. Analysis was done as treated: 66 patients underwent ventral fusion (VF), 69 dorsal fusion (DF), and 28 dorsal laminoplasty (DL). All strategies demonstrated significant improvements. Return to work rate was similar among the three groups. DL had superior SF-36 PCS outcome when compared with VF (P=0.04) and DF (P=0.04). DL patients had fewer complications (42.4% VF vs. 27.5% DF vs. 10.7% DL; P=0.007) and lower hospital charges (VF $90,687 vs. DF $ 111,705 vs. DL $ 55,332; P<0.05).
Conclusion
At 1 year, surgery improved overall quality of life with favorable return to work rates. Dorsal laminoplasty surgery for CSM is associated with greater improvements in health-related quality of life, fewer complications, and lower hospital costs.

9:40-9:50 Fusion for Spondylolisthesis Is Associated with Greater Improvements: A Multicenter Registry Study

Steven Glassman, **Kevin Foley**, Eric Potts, Mohamad Bydon, Michael Wang, Anthony Asher, Erica Bisson, John Knightly, Jonathan Slotkin, Paul Park, Mark Shaffrey, Kai-Ming Fu, Praveen Mummaneni

Introduction
Extensive investigation has not ascertained the ideal surgical management of grade 1 lumbar spondylolisthesis. Using the large, multicenter, prospectively collected Quality Outcomes Database (QOD), we compared 24-month outcomes for patients undergoing decompression alone versus decompression and fusion.
Objectives
Compare decompression and fusion for grade I spondylolisthesis.

Methods
Patients undergoing surgery from 7/1/2014 through 6/30/2016 were identified. The primary outcome measure, 24-month Oswestry Disability Index (ODI) change, was analyzed with univariate and multivariable linear regression. Pain, quality of life, and satisfaction were also analyzed.
Results
Of the 608 patients (85.5% with at least 24-month follow-up) who met the inclusion criteria, 140 (23.0%) underwent decompression alone and 468 (77.0%) underwent decompression and fusion. The 24-month change in ODI was significantly greater in the fusion group than the decompression-only group (-25.8±20.0 vs. -15.2±19.8, p<0.001). Fusion remained independently associated with 24-month ODI change in our multivariable model (B=-7.05, 95% CI -10.70 to -3.39, p=<0.001). Patients in the fusion group were significantly more likely to reach minimal clinically important difference (MCID, 12.8 points) in ODI (73.3% vs. 56.0%, p=<0.001) and to experience significantly greater NRS back pain improvement (-3.8±3.1 vs. -1.8±3.9, p<0.001) at 24 months. Fusion was also independently associated with achieving MCID for ODI at 24 months in our logistic regression model (OR 1.767, 95% CI 1.058-2.944, p=0.029).
Conclusion
The results of our study suggest that decompression plus fusion may offer superior outcomes to decompression alone in patients with grade 1 lumbar spondylolisthesis at 24 months. Longer-term follow-up is warranted to assess whether this effect is sustained.

9:50-10:00 Frailty, Long-Term Outcomes and Management Implications for Type II Odontoid Fractures in the Elderly

Christopher Graffeo, **Michelle Clarke**, Avital Perry

Introduction
Type II odontoid fractures are common and highly morbid injuries in elderly patients. The modified 5-item frailty index (mFI-5) is a validated comorbidity-based tool for risk stratification which has been shown to predict adverse outcomes after various surgeries.
Objectives
Determine whether the mFI-5 predicts long-term outcome following Type II odontoid fractures in the elderly and determine if mFI-5 is useful in operative vs. non-operative treatment decisions.
Methods
A single-center prospective trauma registry was retrospectively reviewed to identify patients over age 79 with Type II odontoid fractures. Prospective outcomes included Abbreviated Injury Scale, Injury Severity Score, and calculated mFI-5. Statistical tests included a Cox proportional hazards model, with frailty score as the dichotomized predictor (frail defined as mFI ≥ 3).
Results
Of 111 patients identified, 106 had complete frailty data and met inclusion criteria. The basic univariate frailty model resulted in a hazard radio for death of HR=2.07 (95%CI=1.25-3.34, p=0.005), for frailty score 3-5 as compared to frailty score 0-2. Adjusting for management strategy (operative vs observation), the frailty score retains statistical significance, with the adjusted HR=2.08 (95%CI=1.25-3.36)
Conclusion
Among elderly patients with type II C2 fractures and no neurologic injury, a frailty score of ≥3 is a significant predictor of mortality, which is independently associated with a 2-fold increase in risk of death, after adjusting for management strategy. Correspondingly, a low frailty index (≤2, using the 5-point scale) may identify patients within this high risk cohort who would be reasonable candidates for operative management.

10:00-10:10 The use of intraoperative sodium fluorescein for diagnostic biopsy of intramedullary spine cord lesions

Jens-Peter Witt, Kevin Lillehei, **Timothy Ung**, Edin Nevzati, Leslie Robinson, Michael Finn

Introduction
Sodium fluorescein-guided microsurgery facilitates resection of intrinsic and metastatic lesions in the brain and may prove to be beneficial when used in the spinal cord. Spinal cord lesions present a unique challenge to neurosurgeons and often lesions are not amendable to resection. Diagnostic biopsy of spinal cord lesion is often challenging and the localization of such lesions intraoperatively is paramount. However, there has been limited research elucidating potential application of sodium fluorescein for such use.
Objectives
Demonstrate the utility of sodium fluorescein for Intramedullary Spinal Surgery.
Methods
Five patients with spinal cord lesions received fluorescein sodium (10%, 3 mg/kg) prior to surgical resection. Intraoperative visualization of fluorescence was performed using microscopes equipped with a Yellow560 filter and diagnostic tumor samples were obtained.
Results
Importantly, no adverse reactions were observed in our five patients. Administration of sodium fluorescein resulted in lesional fluorescent contrast extravasation and facilitated diagnostic tumor biopsy in all five patients. The addition of sodium fluorescein allowed for identification of pathology from normal spinal parenchyma. Pathology confirmed the diagnosis of anaplastic astrocytoma (2), glial tumor (1), EBV lymphoproliferative disease (1), and bacterial abscess (1).
Conclusion
Limited modalities exist facilitating the localization of intramedullary spinal lesions. Sodium fluorescein may be a sensitive and specific in guiding the location of intramedullary spinal lesions when diagnostic biopsy is the goal of surgery.

10:10-10:20 Robot-Assisted vs Freehand Instrumentation in Short-Segment Lumbar Fusion: Experience with Real-Time, Image-Guided Spinal Robot

Nicholas Theodore, A. Karim Ahmed , Ethan Cottrill, Erick Westbroek, Tej Azad, Zach Pennington, Corinna C. Zygourakis, Bowen Jiang, Alex Zhu

Introduction
Rising patient demand for minimally invasive surgery and increased payer emphasis on quality-based payment schema have created a need for technologies that provide consistent, high-quality outcomes for patients undergoing spine surgery. Robot assistance is one such technology.
Objectives
To report the early experience with a novel real-time, image-guided robot system for use in surgical procedures of the spine.
Methods
A consecutive series of patients undergoing robot-assisted one- or two-level TLIF were compared to matched controls who underwent free-hand surgery. Screw accuracy, intraoperative outcomes, and 30-day outcomes were compared.
Results
We identified 56 patients who underwent 1- or 2-level lumbar fusion during the study period: 28 who underwent robot-assisted procedures and 28 matched controls who underwent freehand instrumentation placement. No significant differences were found between the robot-assisted surgery cohort and the freehand

surgery cohorts with respect to matched variables. Patients who underwent robot-assisted surgery had less intraoperative blood loss (266.1±236.8 vs. 598.8±360.2mL; p < 0.001) and shorter hospitalizations (3.5±1.8 vs. 4.5±2.0d; p = 0.01). No differences in complication rates or 30-day outcomes or screw accuracy were noted. Profiling of our initial series reveal an average reduction in operation duration of 4.6 minutes with each additional case.

Conclusion

Patients undergoing robot-assisted fusion experienced less intraoperative blood loss and shorter hospitalizations. The results of this initial experience suggest that the ExcelsiusGPS™ system may provide similar short-term outcomes compared with freehand instrumentation placement.

10:20-10:30 Maximal Safe Resection in Thalamic Gliomas is Superior to Biopsy: Personal Reflections on 40 Cases

Mustafa Baskaya

Introduction

Thalamic gliomas (TGs) are difficult-to-access tumors which has historically high operative morbidity. TGs are commonly regarded as inoperable tumors. Although maximal safe resection (MSR) has become standard for lobar and insular gliomas, the location in the thalamus precludes the same treatment for TGs.

Objectives

Biopsy and adjuvant treatment has long been the mainstay management strategy for TG. We hypothesize that if MSR can be achieved with low morbidity and no mortality, then TG patients would have the chance to receive treatments similar to gliomas in other locations, thereby increasing overall survival.

Methods

A retrospective single-center review was performed for patients harboring TGs who underwent a MSR with at least 80% subtotal resection.

Results

A total of 40 patients were included. The extent of resection was gross-total in 35%, near-total (>95%) in 30% and subtotal (>80%) in 35%. Low-grade tumors comprised one-third of the study group whereas more than half of the patients (51%) had a glioblastoma. There was no operative mortality.Although temporary postoperative motor deficits were observed in 12 patients (30%), all improved during the early postoperative period except one patient who remained with mild hemiparesis. Mean overall survival was 116.8±12.4 months for low-grade, and 20.3±3.4 months for high-grade tumors. Multivariate analysis revealed that histological grade, age, and extent of resection, were independent prognostic factors.

Conclusion

Our results show that MSR yields significantly better outcomes, particularly in younger patients with low-grade tumors. Therefore, we advocate for MSR for most TGs using carefully selected surgical approaches, contemporary intraoperative adjuncts, and meticulous microsurgical techniques.

10:30-11:30 Peer Reviewed Abstract Session VIII: Functional/Trauma/Vascular
Moderators: Bernard Bendok & Sepi Amin-Hanjani

10:30-10:40 Dopamine, serotonin, and norepinephrine micro-fluctuations during conscious choice and subjective experience in humans

Kenneth Kishida, **Charles Branch**, Adrian Laxton

Introduction

The ascending neuromodulatory systems that release the neurotransmitters dopamine, serotonin, and norepinephrine are critical for healthy human brain function. Until recently, it was not possible to monitor the release of these neurotransmitters in the human brain with the temporal resolution necessary to investigate their role in encoding human behavior and conscious experience.

Objectives

We sought to develop an approach to directly monitor dopamine, serotonin, and norepinephrine with sub-second temporal resolution in the human brain.

Methods

We have developed a novel approach, which we call ‘elastic net electrochemistry’, that permits sub-second detection of dopamine, serotonin, and norepinephrine (as well as other neurochemicals of interest). These first-of-their-kind recordings require electrodes implanted in the brain, thus we have deployed our approach in humans undergoing deep brain stimulation electrode implantation surgery and, more recently, in patients undergoing stereo-EEG monitoring. We have paired these novel measurements with tasks designed to investigate the computational underpinnings of human choice behavior and associated moment-to-moment changes in subjective experience.

Results

Simultaneously recorded dopamine and serotonin micro-fluctuations in the striatum encode computational signals critical for learning and ongoing adaptations in behavior. These neurochemically encoded signals correlate with moment-to-moment changes in consciously reported subjective experience. Notably, these neurochemically encoded signals are disrupted in patients taking selective serotonin reuptake inhibitors for depression.

Conclusion

Direct, ultra-fast, intracranial monitoring of dopamine, serotonin and norepinephrine is now possible. Going forward, such work is likely to lead to novel insights into how these neuromodulatory systems contribute to the changes in behavior and subjective feeling associated with psychiatric and neurological dysfunction.

10:40 - 10:50 Intracranially delivered IL-12 secreting CAR T cells recruit host immunity to eradicate heterogeneous GBM

Andrew Barbour, Qi-Jing Li, Kendra Congdon, **John Sampson**, Luis Sanchez-Perez, Steven Shen, Adam Swartz, Carter Suryadevara, David Snyder

Introduction

Glioblastoma (GBM) remains uniformly lethal with an overall survival of <21 months despite surgery, radiation, chemotherapy, and tumor-treating fields. Chimeric antigen receptor (CAR) T cell immunotherapy has induced remarkable efficacy, including complete responses, in many hematologic cancers. However, CAR T cells recognizing a single tumor antigen, such as Epidermal Growth Factor Receptor variant III (EGFRvIII), have failed thus far to completely eradicate GBM. These failures can be partially attributed to the high

antigenic heterogeneity present within GBM tumors and the outgrowth of tumor cells lacking the targeted antigen.

Objectives

We hypothesize that intracranial delivery of CAR T cells secreting cytokines or chemokines aimed at inducing endogenous immunity against tumors antigens other than those targeted by the CAR will result in the eradication of heterogeneous GBM.

Methods

In order to evaluate our hypothesis we generated EGFRvIII-CAR T cells secreting one of four immunomodulatory molecules (IL-12, FLT-3L, CCL-3, and GM-CSF) known to increase T cell immunity. These EGFRvIII-CAR T cells were then delivered intracranially into immunocompetent mice with established orthotopic GBM possessing heterogeneous antigen expression (50%EGFRvIIIPositive: 50%EGFRvIIINegative). Survival was monitored overtime as the efficacy endpoint.

Results

Out of these four molecules, EGFRvIII-CAR T cells secreting IL-12 were the only therapy capable of mediating eradication of heterogeneous GBM in immunocompetent mice. Eradication of heterogeneous tumors required the presence of an intact endogenous immune system.

Conclusion

Therefore, our pre-clinical studies suggest that intracranial delivery of IL-12 secreting EGFRvIII-CAR T cells could eradicate tumors with antigenic heterogeneity and overcome a major limitation in the immunotherapy of solid tumors.

10:50 - 11:00 A New Treatment for Acute TBI – a phase II multicenter trial using novel MRI derivatives as surrogate outcome measures

Howard Eisenberg, J. Marc Simard

Introduction

SUR1-TRMP4, a membrane channel that is only expressed after injury. The open channel results in inward movement of water and causes oncotic cell death. When the receptor binds with glyburide the channel closes. Pre-clinical studies show that glyburide reduces edema in hemorrhagic progression of contusions.

Objectives

We tested whether glyburide was safe and effective in acute TBI. MRI indices of hemorrhage and edema, [free water (FW), mean diffusivity (MD), and tissue water (MDt)] were the outcome measures.

Methods

Baseline MRIs were made at or less than 10 hours from injury and then again at 72+/- 12 hours or if not safe, delayed up to 168 hours post impact. Blood was assessed using SWI. The dose was derived from animal data and a phase 1 study.

Results

28 patients were randomized. Both arms were balanced regarding initial GCS and other indices of injury, and time to second scan. 14 patients had contusions. Indicators of injury severity and time to second scan was also balanced here.

MRI measures of edema were greater in the delayed scan compared with baseline. Hemorrhage, however, increased in the placebo arm and decreased in the drug arm. The MRI indices for contusions when compared with unaffected white matter, showed the drug was associated with greater stability (less progression baseline to second scan) than placebo. The difference between the two arms for all indices were significant (Anova p< 0.02 to 0.004). There were no differences in the AE’s/SAE’s between the two treatment arms.

Conclusion

In the context of this study, glyburide was safe and effective.

11:00-11:10 Dynamic blood brain barrier regulation in mild traumatic brain injury

Gerald Grant

Introduction

While the etiology of moderate and severe TBI is readily visible using MRI and CT, a far greater challenge is associated with the diagnosis of mild TBI (mTBI). We investigated the integrity of the blood-brain barrier (BBB) of professional mixed martial arts (MMA) fighters and adolescent rugby players and correlated the perceived BBB disruption observed with measurement of severity and number of impacts using instrumented mouthguard technology.

Objectives

The overall goal was to correlate the perceived BBB disruption observed with the measurement of severity and number of impacts.

Methods

MMA fighters were examined pre-fight and again within 120 hours post competitive fight, while rugby players were examined pre-season and again post-season or post-match. DCE-MRI, serological analysis of BBB biomarkers, and analysis of instrumented mouthguard data were examined.

Results

We provide pilot data that demonstrates disruption of the BBB occurs in both professional MMA and adolescent rugby, dependent on the level of exposure. We show evidence of a disrupted BBB in several players on DCE-MRI after a full season of competitive play as manifested by increased gadolinium extravasation in periventricular regions and at the depths of the cerebral sulci. Analysis of plasma samples also show increased levels of BDNF and MCP-1.

Conclusion

Our data suggest that biomechanical forces in professional MMA and adolescent rugby lead to BBB disruption. These pilot findings may lead the way to objectively predicting and quantifying neural damage in the context of exposure of the brain to repetitive sub-concussive forces and mild traumatic brain injury.

11:10-11:20 Computer-Learning to Identify High Risk Unruptured Aneurysms and Guide Decision Making: Rupture Resemblance Score

Stephan Munich, Muhammad Waqas, Kenneth Snyder, Hamidreza Rajazbadeh-Oghaz, L. Nelson (Nick) Hopkins, **Adnan Siddiqui**, Hui Meng, **Elad Levy**, Kunal Vakharia, Jason Davies

Introduction

Studies show ruptured intracranial aneurysms have unique morphology and hemodynamics, including higher size ratio, higher oscillatory shear index, and lower wall shear stress. Unruptured intracranial aneurysms (UIAs) that possess these characteristics may be at higher risk of rupturing compared to those without them. Rupture Resemblance Score (RRS) is a data-driven model which can objectively gauge the similarity of UIAs to past ruptured IAs.

Objectives

We explored the clinical application of RRS in management decision of UIAs. We hypothesized that RRS could identify UIAs that resembled ruptured IAs, that may be overlooked.

Methods

We retrospectively (September 2018 and January 2019) collected challenging UIAs discussed in neurovascular conference at our center. RRS scores were compared to unruptured intracranial aneurysm treatment score (UIATS) and the real-world decision.

Results

Twenty-seven (27) patients with 54 UIAs(87% UIAs size <7mm) were included. Average RRS [range: 0.0-1.0] was 0.23±0.31. With a cut-off of RRS=0.3, 24% of the UIAs had high RRS, suggesting they

were at higher risk. UIATS and clinicians in our center endorsed treatment for 33% and 52% of UIAs, respectively. RRS was not significantly different between patients recommended for observation and treatment when UIATS was used. On the other hand, RRS was significantly higher in patients who were recommended to undergo treatment of UIA. Five UIAs had high RRS while UIATS suggested “conservative Management”, four of those received treatment in real-world.

Conclusion

RRS can be used to objectively quantify the similarity of UIAs to past ruptured IAs. We showed that UIATS may overlook the risk of these aneurysms which are treated in the real-world.

11:20-11:30 Distribution and radiologic features of SEDAVFs in a modern single-center series of patients with spinal vascular shunts

Elisa Colombo, **Giuseppe Lanzino**

Introduction

Spinal epidural arteriovenous fistulas (SEDAVFs) are rare pathologic shunts. MRI characteristics are often indistinguishable from spinal dural arteriovenous fistulas (SDAVFs), causing diagnostic uncertainty. Early recognition reduces post-treatment recurrence and guarantees better outcomes. DSA represents the tool to recognize and differentiate SEDAVFs.

Objectives

Raise awareness on SEDAVFs as novel epidemiologic entity. Emphasize similar and distinguishing aspects from SDAVFs.

Methods

Among Mayo Clinic patients evaluated for a spinal arteriovenous shunt between 2000 and 2018, we isolated SEDAVFs, identified by an abnormal connection between extradural arteries and an epidural vein, creating a venous pouch.

Results

213 patients met the inclusion criteria. Relative frequency of SEDAVFs made them the second most common lesions after SDAVFs. Most SEDAVF patients were male, mean age at diagnosis was 63.5 +/- 14.8 years. Lower extremity weakness and mRs 1 were the major clinical characteristics at presentation. Abnormal T2 cord signal was the most represented MR feature at diagnosis; we observed preferential distribution of SEDAVFs in the lumbar spine. On DSA, all SEDAVFs showed an epidural venous pouch with variable drainage. Endovascular obliteration was the preferred treatment for SEDAVFs.

Conclusion

Understanding of SEDAVFs is incomplete, mainly because we lack large case series. This study represents the largest cohort of single-center spinal arteriovenous shunts and the most numerous series of SEDAVFs. In our cohort SEDAVFs are the second most common lesions after SDAVFs. SEDAVF patients’ analysis demonstrates demographics comparable to those reported for SDAVFs. This cohort emphasizes the epidural venous pouch as the fundamental distinguishing feature from SDAVFs.

11:30 -11:40 HDFT as a tool to enhance outcomes in the management of hypereloquent lesions

Fang-Cheng Yeh, Jessica Barrios, David Fernandes, **Robert Friedlander**

Introduction

We measure surgical success if the management of lesions in extreme eloquent brain regions results in lack of neurological deterioration. Surgical management of complex lesions often exposes patients to significant risk of neurological decline. Decline or lack of recovery likely results from surgical interruption of functional white matter pathways. Having an accurate understanding of deep white mater pathways may improve surgical outcomes.

Objectives

To evaluate patients with lesions in hypereloquent areas using high definition fiber tractography (HDFT) with the goal of optimizing neurological outcomes.

Methods

Eleven patients with brainstem cavernous malformations were evaluated using HDFT. HDFT information was used to guide decision of operative timing and approach.

Results

Eleven patients with brainstem cavernous malformations were operated (5-potine, 1-pontomesemcephalic, 1-thalamo-mesencephalic, 1-posterior midbrain, 2-floor 4thventricle). Surgical approaches were 8-subtemporal, 1-infratentorial/supracerebellar and 2-telovelar. Gross total resection was achieved in 9/11. Five (46%) patients had transient worsening of preoperative symptoms or new deficits. All new postoperative deficits improved (average time for improvement 1.8 months). None of the patients had a new permanent deficit. Preoperative symptoms recovered: partially in 7 (64%), and completely in 4 (36%) patients. With a mean follow-up of 37 months (3.1 yr.), there has been one asymptomatic bleed and no symptomatic bleeds (3.0% asymptomatic bleed/year, 0% symptomatic bleed/year). No approach related complications.

Conclusion

HDFT as a surgical adjunct optimizes likelihood of minimizing chances for neurological deterioration and increases chance for neurological improvement following resection of brainstem cavernous malformation. Knowing the status and location of perilesional functional white matter pathways is critical to optimize patient outcome.

11:40-11:50 Break

11:50-12:20 Special Lecture 2
Moderator: Alessandro Olivi
Luca di Montezemolo

12:20 - 1:20 Presidential Address
12:20 - 12:30 Introduction of the Academy President: Mark Johnson
12:30 - 1:20 Presidential Address: *Academia: Quo Vadis?*
Nino Chiocca, MD

7:30 – 8:25 **Special Lecture 3: The Oldfield Lectureship**
7:30 – 7:35 Introduction, Moderator: **Nino Chiocca**

7:35 – 8:05 Oldfield Lecture **Bench to bedside development of a novel STAT3 inhibitor for CNS malignancies**

Daniel Zamler, Ling-Yuan Kong, Jun Wei, Martina Ott, Karl-Heinz Tomaszowski, Anantha Marisetty, John de Groot, Gregory Fuller, **Amy Heimberger**, Waldemar Priebe, Erik Sulman, Cynthia Kassab

Introduction
The signal transducer and activator of transcription 3 (STAT3) pathway is a potent regulator of tumorigenesis and is a key molecular hub of tumor-mediated immune suppression.
Objectives
To target p-STAT3 in brain tumors, we used molecular modeling and medicinal chemistry approaches to create a unique small molecule that achieves high CNS concentrations.
Methods
To be able to administer this drug to human subjects, a unique oral formulation of WP1066 using nanoparticles was devised that markedly increased its in vivo half-life, thereby reducing the dosing frequency.
Results
WP1066 increased survival in a wide variety of preclinical tumor models. In addition to direct tumor cytotoxic effects, WP1066 can restore T cell dysfunction, inhibit Tregs, and block immune suppressive macrophages. In multiple preclinical models of intracerebral tumors, WP1066 used in combination with radiation enhanced median survival time and induced immunological memory that was protective against tumor rechallenge. The combination triggered immunological reprograming in the CNS tumor microenvironment, specifically affecting antigen presentation and T cell-effector functions. In the first-in-man phase I clinical trial of WP1066 (NCT01904123) in patients with recurrent GBM, eligible patients were assigned to a dose based on an accelerated-titration design followed by a 3 + 3 design algorithm. To date, toxicities have been grade I and II, mostly associated with minor bone marrow suppression. Target inhibition of p-STAT3 was verified in the peripheral blood mononuclear cells in subjects receiving WP1066.
Conclusion
Targeting STAT3 in patients with brain tumors is a promising therapeutic strategy.

8:05 - 8:15 NIH Funding Overview: **Russell Lonser**

8:15 - 8:20 NREF Funding Overview: **Regis Haid**

8:20 - 8:25 AAcNS/NREF Young Clinician Award Update – **Brian JA Gill**

8:25 - 8:30 AAcNS/NREF Research Fellowship Grant Update – **Benjamin Grannan**

8:30 - 8:40 American Academy Young Clinician Investigator Award – North America
Single-cellular representations of semantic meaning during natural language perception
Benjamin L. Grannan

8:40 - 8:50 American Academy Young Clinician Investigator Award – Italy
Monitoring language networks in the asleep patient during surgery: an electrophysiological approach - **Davide Giampiccolo**

8:55 – 9:30 **Special Lecture 4:**
8:55-9:00 Introduction of Academy Special Lecturer: Alex Olivi
9:00-9:30 Speaker : Lamberto Frescobaldi, President
Azienda Agricola "Marchesi Frescobaldi" Firenze

9:30 - 10:30 **Peer Reviewed Abstract Session IX: Various topics**
Moderators: Jacques Morcos / Robert Harbaugh

9:30-9:40 **Brain growth and developmental outcome after treatment of post-infectious hydrocephalus in infants in Uganda**

Jody Levenbach, John Mugamba, **Abhaya Kulkarni**, Edith Mbabazi Kabachelor, Vishal Monga, Peter Ssenyonga, Mallory Peterson, Steven Schiff, Ruth Donnelly, Benjamin Warf, Venkateswararao Cherukuri

Introduction
In Uganda, post-infectious hydrocephalus (PIH) in infants is a major health burden. Our randomized trial showed a strong association between brain growth and cognitive outcome 1 year after treatment, with no significant difference between endoscopic versus shunt treatment.
Objective
To present 2 year brain growth and cognitive outcome results for this randomized trial.
Methods
One-hundred infants were enrolled. At 2 years after treatment, developmental outcome (Bayley Scales of Infant Development [BSID-3]) and brain volume (from CT scan) were assessed. The trial was funded by National Institutes of Health R21TW009612/R01HD085853.
Results
Eighty-nine infants were analyzed for 2 year outcome. Raw brain volumes increased between baseline and 24-months (p<0.001), but almost all of this increase was seen exclusively in the first 1 year (p<0.001). Only 3.4% had normal brain volume at 24 months, compared to 24.5% at 12 months. Most patients (70.8%) suffered substantial brain volume loss between 12 and 24 months, despite clinically-successful hydrocephalus treatment. Those suffering substantial brain volume loss had lower scores in all BSID-3 domains. There were significant positive correlations between brain volume and all BSID-3 scores and BSID-3 changes from baseline. None of the brain volume or BSID-3 outcomes were significantly different between treatment arms.
Conclusion
Despite seemingly clinically-successful treatment, the overall outcome for infants with PIH in Uganda is poor, with stagnation of brain growth after the first year. Our results raise questions about the impediments to delayed brain growth and how best to prioritize neurosurgical care and preventive health policy to maximize child health in under-resourced settings.

9:40-9:50 **Impact on Facial Nerve Outcomes and Extent of Resection Using Subperineural Dissection Technique for Surgical Resection**

Yu-Lan Ying, **James Liu**, Robert Jyung, Jorge Naranjo, Naveed Kamal, Gurkirat Kohli

Introduction
There has been recent interest in planned subtotal resection of acoustic neuromas (ANs) followed by radiosurgery to minimize facial nerve injury. However, the risk of recurrence is proportional to the volume of residual tumor. The authors report their experience with attempted maximal resection using a facial nerve-sparing strategy via a subperineural dissection technique.
Methods
A retrospective study was performed on 74 consecutive patients who underwent retrosigmoid (79.7%) or translabyrinthine (20.3%) resection of AN using a subperineural dissection technique. During extracapsular tumor removal, the perineurium of the vestibular nerves are identified and dissected away from the tumor capsule, leaving a thin layer of perineurium as an anatomic buffer overlying the facial nerve. Patients were evaluated for tumor size, extent of resection, facial nerve outcomes, and recurrence.
Results
The mean patient age at surgery was 52.3 years with a mean follow-up of 14.4 months. Majority of the tumors were Koos grade III-IV (64.9%) while 35.1% had Koos grade I-II tumors. Gross-total resection (GTR) and near-total resection (NTR, >95% resection) were achieved in 94.6% of patients. There was a decrease in GTR and increase in NTR, with increased Koos grade I to IV (GTR: 100%, 93.3%, 75%, 42.5%; NTR: 0%, 6.7%, 25%, 50%, respectively). Favorable facial nerve outcomes (House-Brackmann grade I-II) were achieved in 94.6%, overall (100% Koos I-II, 87.5% Koos III, 92.5% Koos IV). The extent of resection did not appear to affect final facial nerve outcome. There was one recurrence (1.4%) that was treated with radiosurgery.
Conclusion
The subperineural dissection technique appears to be useful for preserving facial nerve function when attempting maximal resection of ANs. The perineurium of the vestibular nerves provides an anatomic buffer to avoid direct dissection on the facial nerve. The technique will be demonstrated in the presentation via case examples.

9:50-10:00 Phase 0/1 Clinical Trial of Low-Dose Capecitabine in Recurrent GBM: Global Immune Fingerprinting of Tissue and Blood

Michael Vogelbaum

Introduction
Immunosuppressive myeloid derived suppressor cells (MDSCs) are elevated in GBM patient circulation and tumor tissue. Low-dose 5-FU selectively reduces circulating and tumor MDSC levels and promotes survival in mice with GBM.
Objectives
Determine the immune profile of patients with recurrent GBM after low-dose 5-FU treatment.
Methods
We conducted a phase 0/1 clinical trial in recurrent GBM with low dose capecitabine (5-FU oral prodrug) administered before and after surgery. Eleven patients were enrolled over three escalating dose cohorts ranging from 150 to 450 mg BID (typical clinical dose is 2500 mg BID).
Results
Circulating MDSCs were elevated after surgery in a control cohort as well as in the 150 mg dose cohort; they were lower in the 300 and 450 mg dose cohorts. We used our previously reported approach of mass cytometry (CyTOF) and found significant increases in CD4 central memory T cells, CD8+ effector memory cells, classical monocytes, dendritic cells, macrophages, microglia, and NK cells in tumor tissue. Further, we used an artificial intelligence algorithm to predict, and then validate via manual gating of CyTOF data, a significant

reduction in CTLA-4 expression in lymphocytes and number of CTLA-4+/PD-1+ macrophages. No serious adverse events were observed. OS has been 22.1 months (range: 11.9 – 36.6 months).
Conclusion
This tissue-based clinical-translational study revealed that a low dose chemotherapy approach could reduce circulating MDSCs and increase cytotoxic immune infiltration within the tumor microenvironment. We plan to explore the use of more selective inhibitors of GBM-induced MDSC expansion in combination with immune stimulating therapies to further drive an immune response to GBM.

10:00-10:10 Sexual Dysfunction: Prevalence, Prognosis, and Predictors of Outcomes in Patients Operated for Lumbar Spondylolisthesis

Steven Glassman, Andrew Chan, Kevin Foley, Eric Potts, Mohamad Bydon, Leslie Robinson, Mohammed Alvi, Michael Virk, Michael Wang, Anthony Asher, Erica Bisson, John Knightly, Christopher Shaffrey, Jonathan Slotkin, Regis Haid, Paul Park, Mark Shaffrey, Kai-Ming Fu, Domagoj Coric, **Praveen Mummaneni**, Panagiotis Kerezoudis, Jian Guan

Introduction
There is a paucity of investigation on the impact of spondylolisthesis surgery on back-pain related sexual inactivity.
Objectives
We utilized the prospective Quality Outcomes Database (QOD) registry to investigate predictors of improved sex life postoperatively.
Methods
218 patients who underwent surgery for grade 1 degenerative lumbar spondylolisthesis (DLS) were included who were sexually active. Sex life was assessed by Oswestry Disability Index Item #8 at baseline and 24-month follow-up.
Results
Mean age was 58.0±11.0 years and 108 (49.5%) patients were women. At baseline, 178 patients (81.7%) had sex life impairment. At 24 months, 130 patients (73.0% of the 178 impaired) had an improved sex life. Those with improved sex lives noted higher satisfaction with surgery (84.5% vs. 64.6% would undergo surgery again,p=.002). In multivariate analyses, lower BMI was associated with improved sex life (OR=1.14;95%CI[1.05-1.20];p<.001). In the subgroup of younger patients (age<57 years), lower BMI remained the sole significant predictor of improvement (OR=1.12;95%CI[1.03-1.23];p=.01). In the older patients (age≥57 years)—in addition to lower BMI (OR=1.12;95%CI[1.02-1.27];p=.02)—lower ASA grades (1 or 2) (OR=3.7; 95%CI[1.2- 12.0];p=.02) and ≥4 years of college education (OR=3.9;95%CI[1.2-15.1];p=.03) were predictive of improvement.
Conclusion
Over 80% of patients who present for DLS surgery report a negative effect of the disease on sex life. However, most patients (73%) report improvement postoperatively. Sex life improvement was associated with greater satisfaction with surgery. Lower BMI was predictive of improved sex life. In older patients—in addition to lower BMI—lower ASA grade and higher education were predictive of improved sex life.

10:10-10:20 Cerebro-vascular remodeling following ischemic stroke: cellular and molecular mechanisms.

Katelin Cunningham, **Robert Dempsey**, Umadevi Wesley

Introduction
Focal brain ischemia causes destruction of vascular integrity and neuronal cell death leading to poor functional recovery. Thus, therapeutic strategies for ischemic stroke must emphasize both neuro and

microvascular restoration. Molecular/cytokine signals regulate these processes and also endogenous and exogenous stem cells, and improve post-stroke outcome. However, the number and functional capacity of stem cells are impaired in an ischemic microenvironment, leading to inadequate tissue regeneration and repair.

Objectives

The overall objective is to modulate the ischemic brain microenvironment to enhance stem cell survival and function for improving post-stroke recovery and cognitive abilities of patients affected by cerebrovascular diseases.

Methods

Cellular, biochemical and molecular, proteomics, gene arrays, and in vitro oxygen glucose deprivation approaches were used. Pre-clinical animal models subjected to focal ischemia through middle cerebral artery occlusion were used to examine the therapeutic effects of selected molecules.

Results

Expression of cytokines including galectin-3 (Gal-3) and osteopontin were up-regulated in the ischemic brain following ischemia-reperfusion. Blocking of these cytokines decreased neuroblast and blood vessel numbers in vivo. Administration of Gal-3 increased CD31 positive blood vessels in the ischemic brain, and significantly decreased the infarct size and improved neurological functional recovery. Gal-3 increased in vitro mesenchymal stem and neuronal cell survival under ischemic conditions through activation of anti-apoptotic AKT, integrin-linked kinase (ILK), an angiogenic factor, and decreased levels of pro-apoptotic caspase-3.

Conclusion

Cytokines including Gal-3 promote stem cell survival, increase angiogenesis, and thus are potential therapeutic agents for enhancing restoration of the neuro-vascular unit to improve cognitive abilities and neurological functional recovery after ischemic stroke.

10:20-10:30 Glioblastoma organoids: A model system for patient-specific therapeutic testing

Fadi Jacob, Donald O'Rourke, Ryan Salinas, Phuong Nguyen, Hongjun Song, Saad Sheikh, Maclean Nasrallah, **Steven Brem,** Radhika Thokala, Guo-Li Ming, Daniel Zhang, Jay Dorsey, Stefan Prokop

Introduction

Glioblastoma remains invariably lethal due to its aggressive and invasive nature. It is increasingly appreciated that molecular heterogeneity between tumors and within tumors likely contributes to lack of treatment advances.

Objectives

To characterize and test glioblastoma organoids for patient-specific treatment responses.

Methods

To maintain the inherent heterogeneity of glioblastoma, we employed a novel method to rapidly culture glioblastoma organoids (GBOs) directly from neurosurgical resection. To minimize selection bias, cultures were generated from fresh glioblastoma tissue in media free of serum, exogenous EGF/FGF, and matrigel. Histologic and sequencing analyses assessed similarity to primary tumors. Leveraging clinical sequencing data, selected GBOs were treated with radiation/temozolamide, targeted inhibitors, and CAR-T immunotherapy.

Results

Rounded GBOs form within 2 weeks and maintain similarity to the primary tumor by histology and sequencing. Radiation/temozolamide treatment led to a decrease in the percentage of KI67+ cells in select tumors with some evidence of correlative radiographic response. GBO response to gefitinib treatment was specific to EGFR altered tumors. Two GBOs had downstream NF1 mutated that responded to MEK inhibition. One GBO line was found to have a PI3K mutation and responded dramatically to mTOR inhibition. One tumor with EGFRviii expression was treated with CAR-T immunotherapy. Two weeks

following initial CAR-T exposure, we observed antigen loss and decreased KI67+ cells, which was attenuated by dexamethasone.

Conclusion

This novel culturing method of GBOs maintains intertumoral and intratumoral heterogeneity for therapeutic testing. As clinical sequencing because increasingly prevalent, GBOs may become a valuable tool to functionally test mutation-specific treatment strategies in a rapid and patient-specific manner.

10:30-10:45 Break

10:45-11:55 Peer Reviewed Abstract Session X: Various topics
Moderators: Michael McDermott / Aviva Abosch

10:45 - 10:55 Outcomes from Asleep and Awake Dominant Temporal Lobe Glioma Surgery: Risk, Extent of Resection, and Survival

Jacob Young, Philip Theodosopoulos, Shawn Hervey-Jumper, **Michael McDermott**, Mitchel Berger, Edward Chang, Manish Aghi, Caleb Rutledge

Introduction

Awake speech language mapping is a recognized standard for safely removing dominant hemisphere gliomas, although it requires an experienced, multidisciplinary team. We sought to compare the outcomes for asleep versus awake dominant temporal lobe glioma surgery to determine if there are instances were asleep surgery yielded comparable outcomes to awake surgery.

Objectives

To evalaute risk and outcomes with 2 apporaches to craniotomy in the dominant temporal lobe.

Methods

The electronic medical record of patients with pathologically proven newly diagnosed left temporal lobe glioblastomas who underwent resection at UCSF between 2005-2018 were retrospectively reviewed.

Results

117 patients with mean age of 57.4 years (range 15 – 79 years) were included. 63 patients underwent asleep craniotomy (63.5% had pre-operative language deficit) and 54 patients underwent awake craniotomy (83.3% had pre-operative language deficit). At 6 months, only 3.7% of patients who underwent awake craniotomy had a persistent language deficit compared to 15.9% of patients who underwent asleep craniotomy (p = 0.02). Patients with have awake operations are more likely to get discharged to home (96% vs 75%, p = 0.001), had a shorter length of stay (4.2 days vs 7.1 days, p < 0.001), and more commonly a gross total resection was achieved (53.7% vs. 30.2%, p = 0.01), and had longer overall survival (median 1.78 years vs 1.10 years, p = 0.03).

Conclusion

Awake craniotomy resulted in fewer persistent language deficits than patients who underwent asleep craniotomy. Patients who underwent awake craniotomy had higher rates of gross total resection, were more like to be discharged to home, and had longer overall survival.

10:55-11:05 Real-time CED of Nanoliposomal CPT-11 for recurrent GBM: Interim results of a phase I clinical trial

John Bringas, Jennifer Clarke, Krystof Bankiewicz, Jesus Eduardo Rodriguez Almaraz, Nicholas Butowski, Alastair Martin, Susan Chang, **Manish Aghi**, Nancy Ann Oberheim Bush, Karishma Kumar, Jennie Taylor

Introduction

Chemotherapy for high-grade gliomas (HGGs) is limited by the blood-brain-barrier and systemic toxicity. Convection enhanced delivery (CED) of chemotherapy addresses these challenges via continuous, low–positive-pressure intratumoral bulk flow.

Objectives

Based on encouraging preclinical data, we launched a phase I clinical trial (Clinicaltrials.gov NCT02022644) of real-time CED of liposomal-irinotecan (Onivyde) in recurrent HGG patients. An advance of this trial is real-time CED, in which MRI continuously visualizes CED in real-time by co-convecting gadolinium to monitor intratumoral delivery, enabling corrective catheter repositioning.

Methods

This 3x3 dose-escalation trial uses 20 and 40 mg/mL Onivyde. Onivyde and gadolinium were co-infused via the same catheters in one-time delivery at rates up to 50 µL/min. Infusate volume and dose were personalized to tumor volume, ranging from 20-680 mg Onivyde via up to four 14G catheters with 10-15 mm tips. Tumor diameters of 1–4 cm and infused volumes of 2–17 mL were allowed.

Results

Thirteen recurrent HGG patients with tumor volumes=0.8-9.3 cm3 (mean=3.9 cm3) have been treated to date, with 1-4 hour infusion times (mean=1.8 hours). Eight of 10 patients with sufficient post-treatment time lived over a year post-treatment, which is encouraging since median survival for recurrent HGG is 9 months.Utilizing imaging software, we correlated pre-infusion modeling of drug distribution with post-infusion imaging. CED ensured that the volume of distribution (Vd) to volume infused (Vi) ratio averaged 1.7 (range=0.3-3.5), while real-time imaging enabled 49% average tumor coverage (range=23.8%-91.1%).

Conclusion

Image-guided distribution allows for safe real-time CED of Onivyde into recurrent HGG. Real-time CED maximizes tumor coverage and warrants further studies with repeat dosing.

11:05-11:15 Leptomeningeal dissemination, a sinister pattern of medulloblastoma growth

Livia Garzia, Michael Taylor, **Daniel Fults**

Introduction

Leptomeningeal dissemination (LMD) is the defining pattern of metastasis for medulloblastoma. The fact that medulloblastomas rarely metastasize outside the central nervous system but rather almost exclusively to the spinal and intracranial leptomeninges has fostered the long-held belief that medulloblastoma cells spread directly through the cerebrospinal fluid (CSF). Recent experimental evidence reveals an alternative scheme in which medulloblastoma cells can enter the bloodstream and subsequently home to the leptomeninges.

Objectives

We sought to build a conceptual model to visualize the cellular events in dispersal of medulloblastoma cells through the CSF, analogous to the invasion-metastasis cascade of hematogenous metastasis of carcinomas.

Methods

We reviewed selected molecules for which current experimental evidence is strong enough to explain how the physiological effects of these molecules contribute mechanistically to LMD. We assigned the molecules to three stages of the LMD cascade: initiation, dispersal, and colonization.

Results

The LMD cascade is based on the molecular themes that (1) transcription factors launch cell programs that mediate cell motility and invasiveness and maintain tumor cells in a stem-like state, (2) disseminating medulloblastoma cells escape multiple death threats by subverting apoptosis, and (3) inflammatory cytokine signaling promotes LMD by creating an oncogenic microenvironment.

Conclusion

Although LMD is responsible for virtually 100% of medulloblastoma deaths, it remains the least understood part of medulloblastoma pathogenesis. The LMD cascade can serve as a framework for organizing our thinking about LMD as new molecular mediators of LMD are discovered in the future.

11:15-11:25 Characteristics of Clots Retrieved by Mechanical Thrombectomy Associated with Stroke Etiology and Device Performance

Vincent Tutino, Matthew McPheeters, Muhammad Waqas, John Tomaszewski, Kenneth Snyder, Shashiprakash Avinash , **Adnan Siddiqui**, Michael Tso, Hui Meng, Elad Levy, Kunal Vakharia, Pinaki Sarder

Introduction

The introduction of mechanical thrombectomy (MT) devices for the treatment of acute ischemic stroke enabled the extraction and analysis of human clots. Histological structure and molecular composition of the retrieved clot material may provide information about underlying stroke pathology, and could be biomarkers to diagnose cryptogenic strokes.

Objective

Our objective was to investigate associations between the histology and biology of retrieved clots, and stroke etiology, efficacy of MT, and recanalization outcomes.

Methods

Clot samples from 50 stroke patients with large-vessel occlusion were collected during MT recanalization into tubes of either 10% phosphate-buffered formalin (for histology) or RNALater (for gene expression analysis). H&E–stained specimens were quantitatively analyzed to determine relative fractions of red blood cells, white blood cells, and fibrin/platelet aggregates. Extracted clot RNA was subjected to next-generation RNA sequencing on the NovaSeq platform (Illumina). Clinical and interventional parameters, as well as stroke subtype by TOAST criteria were also collected.

Results

Cardioembolic thrombi had significantly higher proportions of fibrin/platelet aggregates, significantly less erythrocytes, and more leukocytes than large artery atherosclerosis thrombi. The number of passes to achieve recanalization was significantly higher in clot samples that were fibrin/platelet-rich. Clot composition was not correlated with change in (delta) NIHSS and reperfusion outcomes defined by the TICI score. RNA sequencing analysis for biological study of the clots is still underway.

Conclusion

Quantitative evaluation of clot composition may help to distinguish between different stroke subtypes. Clot composition may play a role in successful recanalization by MT devices.

11:25-11:35 Integration of 5-ALA and CEUS in the Surgical Resection of High Grade Glioma

Giuseppe M. Della Pepa, **Alessandro Olivi**

Introduction

Survival benefit in maximizing resection in high grade gliomas (HGG) has been demonstrated by numerous studies. The infiltrative nature of HGG has been an overwhelming obstacle and several technological advances (some of them quite expensive such as iMRI or iCT) have been introduced to identify residual neoplastic tissue.

Objectives

This study evaluates the role of the integration of the use of 5-aminolevulinic acid (5-ALA) with microbubbles contrast enhancement ultrasound (CEUS) in the identification of residual neoplastic disease and the related impact on the extent of resection (EOR), progression free survival (PFS) and overall survival (OS)

Methods

270 HGG procedures were retrospectively studied. Cases were stratified according to the surgical procedures into four groups: 5-ALA + CEUS guided surgeries, 5-ALA guided surgeries, CEUS guided surgeries and conventional microsurgical procedures.

Results

Patients undergoing conventional microsurgical procedures displayed worse EORs when compared to those operated with the assisted techniques (5-ALA and CEUS procedures). Both 5-ALA and CEUS techniques improved the EOR with respect to standard microsurgical procedures. However, it is their association which yielded the best results in terms of EOR. Median EOR percentage and the number of supramarginal resections were therefore superior in the 5-ALA+CEUS group compared with the others. This was found to have demonstrated positive repercussions on PFS and OS in our series.

Conclusion

In terms of EOR, best results can be achieved through a combination of both techniques (5-ALA + CEUS). Compared with other intraoperative imaging techniques, this approach is a real-time, reproduceable, relatively inexpensive technique which ultimately can improve the outcome of our patients.

11:35-11:45 Mesenchymal Stem Cell Delivery of Oncolytic Adenovirus Delta-24-RGD Following Surgical Resection of Glioblastoma

Sricharan Gopakumar, Shawn Hingtgen, **Frederick Lang**, Joy Gumin, Matthew Ewend

Introduction

The oncolytic virus Delta-24-RGD is a novel treatment of GBM. Prior studies have examined intratumoral injection of “naked” Delta-24-RGD into unresected recurrent GBM, and an ongoing clinical trial is examining the potential of using human Mesenchymal Stem Cells (hMSCs) to deliver Delta-24-RGD endovascularly. However, the ideal delivery strategy of Delta-24-RGD after surgical resection of newly diagnosed GBM is not defined.

Objectives

To address this clinical problem, we undertook a series of translational experiments to determine the efficacy of delivering hMSCs loaded with Delta-24-RGD (hMSC-D24) into the surgical resection cavity using a fibrin-scaffold.

Methods

For in vitro studies, MSCs-D24 were seeded in a fibrin scaffold or in PBS in the upper wells of transwell plates with U87 placed below, and U87 viability was determined after 7 days. For in vivo studies, mCherry-Luciferase-U87 was implanted into the brains of athymic mice (N=16). After fluorescence-guided surgical resection, hMSCs (control) or hMSCs-D24 were delivered into the resection cavity using a fibrin scaffold. Tumor recurrence was assayed by Bioluminescence Imaging.

Results

In transwell experiments, hMSCs-D24 in fibrin were as effective as hMSCs-D24 alone in killing U87 cells. In in vivo studies, treatment of the post-resection cavity with hMSCs-D24 suspended in fibrin resulted in sustained retention of hMSCs-D24 within the tumor bed, and in statistically significant improved survival compared with controls, with 50% of animals demonstrating complete tumor eradication (p < 0.05).

Conclusion

Delivering DNX-2401 into the post-resection surgical cavity using hMSCs seeded in a fibrin-scafold is capable of eradicating residual GBM. These studies support the clinical translation of this approach to surgically resected newly-daigniosed GBM.

11:45-11:55 An Epigenetic Liquid Biopsy Machine Learning Algorithm to Predict Glioma and Glioma Subtypes

Steven Kalkanis

Introduction

In patients with newly diagnosed intracerebral lesions based on MRI, gliomas are often suspected, but other conditions are possible. Biopsy can be challenging due to eloquent and/or deep location. In this prospective, blinded study, analysis of plasma isolated cell-free DNA and exosome mRNA and miRNA from glioma patients and cancer-free volunteers was used to predict disease.

Objectives

Results were then used to develop a machine learning algorithm to predict glioma progression and response to therapy based on epigenetic biomarkers.

Methods

Plasma was drawn from 52 newly-diagnosed glioma patients (28 high grade, 10 low grade) and 14 healthy volunteers. DNA and RNA were sequenced using Next Generation Sequencing, and Digital Droplet PCR was used for detection of trace molecular artefacts. Multianalyte processing yielded data that was harmonized and interpreted through an Artificial Intelligence based algorithm to assess for glioma while assigning grade. EGFRvIII, TP53 and IDH1 mutations were also analyzed and compared to tumor specimen molecular testing.

Results

96% (27 of 28) of high grade glioma patients were deemed to have gliomas by plasma testing. 82% of low grade patients were correctly graded. Of 10 healthy controls, 8 were deemed cancer-free. Two patients were suspicious for malignancy. IDH1, TP53 and EGFRviii and mutation had concordance at 84 %, 82% and 75%, respectively.

Conclusion

Machine learning genetic analysis was highly sensitive for detecting glioma and grade. Further testing will follow, with the goal of using this modality to assess response to therapy and direct patients to appropriate clinical trials. Prognostic epigenetic liquid biopsies could also be used for monitoring during active treatment.

12:00 Closing Remarks Meeting Adjourn
2020 Scientific Chair - Aviva Abosch

Immediately following Adjournment, Lamberto Frescobaldi will host a wine tasting entitled "*A Journey Through Tuscany*"

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H. THOMAS BALLANTINE, JR	1951	1996
WILLIAM F. BESWICK	1959	1971
EDWIN B. BOLDREY	1941	1988
E. HARRY BOTTERELL	1938	1997
ROBERT BOURKE	1983	1996
SPENCER BRADEN, Founder		1969
F. KEITH BRADFORD	1938	1971
ALBINO BRICOLO	2002	2015
JEAN BRIHAYE	1975	1999
KARL-AUGUST BUSHE	1972	1999
HOWARD BROWN	1939	1990
FERNANDO CABIESES	1966	2009
JUAN CARDENAS	1966	1996
HARVEY CHENAULT	1949	2006
SHELLEY CHOU	1974	2001
JUAN CARLOS CHRISTENSEN	1970	2003
GALE CLARK	1970	1996

	Elected	Deceased
W. KEMP CLARK	1970	2007
DONALD COBURN	1938	1988
EDWARD CONNOLLY	1972	2015
WINCHELL McK. CRAIG (Honorary)	1942	1960
EDWARD DAVIS	1949	1988
RICHARD DESAUSSURE, JR	1962	2008
PEARDON DONAGHY	1970	1991
CHARLES DRAKE	1958	1998
FRANCIS ECHLIN	1944	1988
DEAN ECHOLS, Founder		1991
GEORGE EHNI	1964	1986
ARTHUR ELVIDGE	1939	1985
THEODORE ERICKSON	1940	1986
JOSEPH EVANS, Founder		1985
WILLIAM H. FEINDEL	1959	2014
ROBERT FISHER	1955	2003
ELDON L FOLTZ	1960	
JOHN FRENCH	1951	1989
LYLE FRENCH	1954	2004
JAMES GALBRAITH	1947	1997
HENRY GARRETSON	1973	2007
PHILIP GORDY	1968	2017
SIDNEY GOLDRING	1964	2004
EVERETT GRANTHAM	1942	1997
JOHN GREEN	1953	1990
JAMES GREENWOOD, JR.	1952	1992
WESLEY GUSTAFSON	1942	1975
WALLACE HAMBY	1941	1999
HANNIBAL HAMLIN	1949	1982
JOHN HANBERY	1959	1996

	Elected	Deceased
JOHN HANKINSON	1973	2007
MAJOR GEN. GEORGE HAYES	1962	2002
MARK PETER HEILBRUN	1984	2010
E. BRUCE HENDRICK	1968	2001
JESS HERRMANN	1938	1944
HENRY HEYL	1951	1975
JULIAN HOFF	1975	2007
HAROLD HOFFMAN	1982	2004
EDGAR HOUSEPIAN	1976	2014
WILLIAM HUNT	1970	1999
OLAN HYNDMAN	1942	1966
SHOZO ISHII	1975	2012
FABIAN ISMAT	1989	2019
KENNETH JAMIESON	1970	1976
JOHN JANE, SR.	2011	2015
PETER JANNETTA	1994	2016
SIR GEOFFREY JEFFERSON (Honorary)	1951	1961
HANS-PETER JENSEN	1980	2000
RICHARD JOHNSON	1974	1997
WILLIAM KEITH, Founder		1987
ROBERT KING	1958	2008
KATSUTOSHI KITAMURA	1970	2005
ROBERT KNIGHTON	1966	2004
RICHARD KRAMER	1978	2001
HUGO KRAYENBUHL (Honorary)	1974	1985
KRISTIAN KRISTIANSEN	1967	1993
THEODORE KURZE	1967	2002
LAURI LAITINEN	1972	2007
THOMAS LANGFITT	1971	2005
SANFORD LARSON	1989	2012

	Elected	Deceased
GUY LAZORTHES (Honorary)	1973	2018
WALPOLE LEWIN	1973	1980
RAEBURN LLEWELLYN	1963	2009
VALENTINE LOGUE (Honorary)	1974	2000
H.C. RUEDIGER LORENZ	1998	2008
HERBERT LOURIE	1965	1987
JOHN LOWREY	1965	2005
ALFRED LUESSENHOP	1977	2009
WILLEM LUYENDIJK	1973	1995
ROBERT MACIUNAS	1999	2011
ERNEST MACK	1956	2000
M. STEPHEN MAHALEY	1972	1992
LEONARD MALIS	1973	2005
GEORGE MALTBY	1942	1988
FRANK MARGUTH	1978	1991
DONALD MATSON	1950	1969
FRANK MAYFIELD, Founder		1991
AUGUSTUS McCRAVEY	1944	1990
KENNETH McKENZIE (Honorary)	1960	1964
J. MICHAEL MCWHORTER	1989	2004
WILLIAM MEACHAM	1952	1999
JAMES MEREDITH	1946	1962
J. DOUGLAS MILLER	1988	1995
W. JASON MIXTER (Honorary)	1951	1968
EDMUND MORRISSEY	1941	1986
JOHN F. (SEAN) MULLAN	1963	2015
FRANCIS MURPHEY, Founder		1994
BLAINE NASHOLD, JR.	1967	2014
GOSTA NORLEN (Honorary)	1973	1985
FRANK NULSEN	1956	1994

	Elected	Deceased
SIXTO OBRADOR (Honorary)	1973	1978
GUY ODOM	1946	2001
ROBERT OJEMANN	1968	2010
EDWARD OLDFIELD	1975	2017
PIETRO PAOLETTI	1989	1991
ANDREW T. PARSA	2012	2015
WILDER PENFIELD (Honorary)	1960	1979
HELMUT PENZHOLZ	1978	1985
PHANOR PEROT, JR.	1970	2011
BERNARD PERTUISET (Honorary)	1986	2000
BYRON CONE PEVEHOUSE	1964	2010
HANS-WERNER PIA	1978	1986
J. LAWRENCE POOL	1940	2004
ROBERT PUDENZ	1943	1998
JOHN E. RAAF, Founder		2000
B. RAMAMURTHI	1973	2003
AIDAN RANEY	1946	2002
RUPERT B. RANEY	1939	1959
JOSEPH RANSOHOFF	1965	2001
THEODORE RASMUSSEN	1947	2002
BRONSON RAY (Honorary)	1992	1993
DAVID REEVES	1939	1970
DAVID REYNOLDS	1964	1978
ALBERT RHOTON, JR.	1984	2016
HUGO RIZZOLI	1973	2014
THEODORE ROBERTS	1976	2007
JAMES T. ROBERTSON	1971	2019
R. C. L. ROBERTSON	1946	1985
STEWART ROWE	1938	1984
KEIJI SANO (Honorary)	1975	2011

	Elected	Deceased
RICHARD SCHNEIDER	1970	1986
KURT-FRIEDRICH SCHURMANN	1978	2005
HENRY SCHWARTZ	1942	1988
WILLIAM SCOVILLE	1944	1984
R. EUSTACE SEMMES (Honorary)	1955	1982
C. HUNTER SHELDEN	1941	2003
ROBERT SMITH	1989	20036
SAMUEL SNODGRASS	1939	1975
GLEN SPURLING (Honorary)	1942	1968
C. WILLIAM STEWART	1948	1948
KENICHIRO SUGITA	1988	1994
THORALF SUNDT, JR.	1971	1992
ANTHONY SUSEN	1965	2008
HENDRIK SVIEN	1957	1972
HOMER SWANSON	1949	1987
WILLIAM SWEET	1950	2001
SUZIE CUNNINGHAM TINDALL	1990	2016
ALFRED UIHLEIN	1950	1990
JOHN VAN GILDER	1980	2007
A. EARL WALKER	1938	1995
EXUM WALKER	1938	2001
ARTHUR WARD, JR.	1953	1997
E. SYDNEY WATKINS	1975	2012
THOMAS WEAVER, JR.	1943	1985
W. KEASLEY WELCH	1957	1996
BENJAMIN WHITCOMB	1947	1998
ROBERT WILKINS	1973	2017
CHARLES B. WILSON	1966	2018
BARNES WOODHALL	1941	1985
FRANK WRENN	1973	1990

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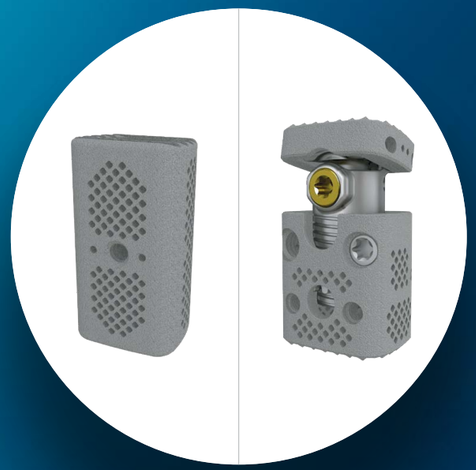

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