Supplemental Material

Table of Contents

- 1. Supplemental Table 1: Description of Experts
- 2. Supplemental Table 2: Invited Non-Participants
- 3. Supplemental Table 3: Areas of Consensus Including Statistical Results
- 4. Supplemental Table 4: Areas of Agreement without Consensus
- 5. Supplemental Table 5: Areas without Agreement
- 6. Supplemental Figure 1: Context-specific Devices and Measurements
- 7. Supplemental Figure 2: Reporting Elements
- 8. Supplemental Material 1: Round One Delphi Survey
- 9. Supplemental Material 2: Round Two Delphi Survey

Supplemental Table 1: Description of Experts

Question	Round One, n(%)	Round Two, n(%)
What is your training background?**	•	•
Neurology	13 (43.3)	18 (51.4)
Pediatric neurology	5 (16.7)	5 (14.3)
Neurosurgery	4 (13.3)	4 (11.4)
Intensive care	2 (6.7)	2 (5.7)
Internal medicine	2 (6.7)	2 (5.7)
Nursing	1 (3.3)	2 (5.7)
Anesthesia	1 (3.3)	1 (2.9)
Emergency medicine	0 (0)	1 (2.9)
Pediatrics	2 (6.7)	1 (2.9)
Surgery	0 (0)	0 (0)
Which is your current primary practice?**		
Neurocritical care	22 (73.3)	29 (82.9)
Neurosurgery	3 (10)	5 (14.3)
Epilepsy and/or clinical neurophysiology	2 (6.7)	4 (11.4)
Intensive care	2 (6.7)	4 (11.4)
Neurology	1 (3.3)	4 (11.4)
Pediatrics	0 (0)	3 (8.6)
Pediatric critical care	2 (6.7)	1 (2.9)
Emergency medicine	0 (0)	1 (2.9)
Neurohospitalist	1 (3.3)	0 (0)
Anesthesia	0 (0)	0 (0)
Internal medicine	0 (0)	0 (0)
Surgery	0 (0)	0 (0)
Which population do you primarily care for?**		
Adults	24 (80)	30* (85.7)
Children	6* (20)	6* (17.1)
Neonates	1* (3.3)	2* (5.7)
How many years have you been in independent practice?		
None (trainee)	0 (0)	0 (0)
Up to 5 years	5 (16.7)	5 (14.3)
6-10 years	9 (30)	12 (34.3)
> 11 years	16 (53.3) 18 (51.4)	
What is your academic research time allocation (%)?		
>50% of my time is protected for research	10 (33.3)	11 (31.4)
26-50% of my time is dedicated research time	7 (23.3)	5 (14.3)
10-25% of my time dedicated research time	8 (26.7)	11 (31.4)
<10% of my time is dedicated research time	3 (10)	5 (14.3)
100% of my time is dedicated to clinical duties	1 (3.3)	2 (5.7)
Non-academic clinical practice	1 (3.3)	1 (2.9)

*One respondent in Round 1 selected both children and neonates; one respondent in Round 2 selected adult and child populations, and two selected children and neonates.

**Respondents were able to select more than one choice

Supplemental Table 2: Invited Non-Participants (n=23)

Primary Specialty	n(%)
Neurocritical Care	15 (65)
Intensive Care	5 (22)
Clinical neurophysiology	2 (9)
Pediatric Critical Care	1 (4)

Supplemental Table 3: Areas of Consensus Including Statistical Results

	Round Two		Round Three	Round Three	
	Median IQR		Strongly	Strongly	
	[IQR]	Difference	Agree (%)	Disagree (%)	
Clinical Considerations for Utility of MNM					
Level of consciousness	8 [7-9]	2	19 (100)	0 (0)	
Underlying disease or diagnosis	8 [7-8]	1			
Potential risk for secondary brain injuries or secondary	8 [8-9]				
neurodeterioration		1			
Structural imaging findings	7 [6.5-7]	0.5			
Confounding factors clouding the neurological	7 [6 9]	2	18 (05)	1 (5)	
examination	7 [0-8]	Z	18 (93)	1(3)	
Desire to understand the pathophysiology underlying	7 [6.5-8]				
brain dysfunction (e.g., diffuse vs focal injury processes)		1.5			
Guiding individualized management decisions	8 [8-8.5]	0.5			
Informing goals or thresholds for targeted management	8 [8-8]	0			
Abstaining from or de-escalating a potential therapy or	8 [7-8]				
treatment that might cause harm?		1			
Case Presentations: Invasive and/or Non-invasive Monitor	ring				
Non-surgical traumatic brain injury who remains	9 [8-9]				
comatose (GCS 8 or less) after initial resuscitation		1			
Surgical traumatic brain injury who remains comatose	9 [8-9]				
(GCS 8 or less) after appropriate evacuation and/or					
decompression?		1			
Aneurysmal subarachnoid hemorrhage who remains	9 [8-9]				
comatose (Hunt-Hess 4-5) after initial resuscitation					
and/or treatment of hydrocephalus?		1			
Aneurysmal subarachnoid hemorrhage who has	9 [8.5-9]				
developed vasospasm or vasospasm-associated delayed					
cerebral ischemia and who is comatose or ventilated on					
sedation?		0.5			
Supratentorial (lobar or basal ganglia) intracerebral	7 [7-8]				
hemorrhage without intraventricular hemorrhage who is					
comatose (GCS 8 or less) after initial resuscitation					
and/or treatment of hydrocephalus?		1			
Supratentorial (lobar or basal ganglia) intracerebral	7 [7-8.5]				
hemorrhage with intraventricular hemorrhage who is					
comatose (GCS 8 or less) after initial resuscitation					
and/or treatment of hydrocephalus?		1.5			
Minimum Necessary Devices					
Intracranial pressure (ICP)	9 [9-9]	0			
Cerebral perfusion pressure (CPP)*	8 [8-9]	1			

Brain tissue avgen (Pbt02 or Pti02) 8 [7 8.5] 1.5 Continuous scalp EEG 9 [8-9] 1 Cuntituitive pupillometry 8 [7-8.75] 1.75 Arterial blood pressure (ABP) 9 [9-9] 0 Cardiac telemetry (EGG) 9 [8-9] 1 Continuous core body temperature* 9 [8-9] 1 Continuous core body temperature* 9 [8-9] 1 Minimum Mecessary Access 8 [7-8] 1 Bedside visualization or display of a single numeric value displayed on a device stable in a patient care area 8 [7-8] 1 Bedside visualization or display of single measurement trended over time, e.g., a graph of a time-series displayed on a device stable in a patient care area 8 [7-8] 1 measurement values together on the same screen, e.g., multiple numeric measurement values from different devices displayed on the same screen, e.g., a graph of several time series from different devices displayed on the same screen and visible in a patient care area* 8 [7-8] 1 Recess to data with high temporal resolution (10 or more data points every minute) including clinically standard data such as heart rate, arterial blood pressure or in traceranial pressure avacems muscluding clinically standard data such as heart rate, arterial blood pressure or in traceranial pressure avacems met values together on a single panel, tab, or screen contextual data* 8 [7-9] 1.5<	End-tidal capnography (ETCO2)	8 [7-8.5]	1.5		
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Ability to visualize or display neuromonitoring data in real-time remotely (from a separate reading room or from home) 9 [7.5-9] 1.5	neuromonitoring measurements to display				
real-time remotely (from a separate reading room or	Ability to visualize or display neuromonitoring data in	9 [7 5-9]	15		
from home)	real-time remotely (from a senarate reading room or	5[7.5-5]	1.5		
	from home)				

Ability to manipulate and review displayed	8 [8-9]	1		
neuromonitoring data in real-time remotely (from a				
separate reading room or from home), e.g., choosing				
specific neuromonitoring measurements to display or				
zooming in or out of the data				
Ability to display neuromonitoring data remotely linked	8 [7-9]	2	21 (95)	1 (5)
with bedside annotations that indicate clinical events or				
other contextual data				
Ability to display neuromonitoring data remotely linked	8 [7-9]	2	20 (91)	2 (9)
with Electronic Health Record information, e.g.,				
laboratory values or medication administration				
information				
Ability to set alarms or thresholds to alert staff at	7 [7-8]	1		
bedside, e.g., via flashing colors or alarm sounds				
Bedside visualization or display of summary or aggregate	8 [7-9]	2	20 (91)	2 (9)
data such as "Area Under the Curve", "Burden" or				
"Dose" on a device visible in a patient care area.				
Ability to access neuromonitoring data in real-time for	8 [7-8]	1		
use in data analytic tools either through a network				
interface or hardware connection.				
Minimum Necessary Work				
Most intensivists staffing an ICU and caring for patients	3 [3-3]	0		
with brain injuries are able to adequately integrate and				
interpret multimodality neuromonitoring data as part of				
daily clinical care in order to make management				
decisions**				
Most intensivists staffing an ICU and caring for patients	3 [2-3]	1		
with brain injuries do have adequate time to fully review				
all available multimodality neuromonitoring data as part				
of daily clinical care**				
Most intensivists staffing an ICU and caring for patients	2 [1-3]	2	1 (5)	21 (95)
with brain injuries have all the necessary technology to				
integrate and interpret multimodality neuromonitoring				
data as part of daily clinical care**				
Most intensivists staffing an ICU and caring for patients	2 [1-3]	2	1 (5)	21 (95)
with brain injuries have technology sufficient to				
troubleshoot device errors and to identify artifactual or				
erroneous multimodality neuromonitoring data. *,**				
Most intensivists staffing an ICU and caring for patients	8 [7-8.5]	1.5		
with brain injuries would find regularly written reports				
summarizing multimodality neuromonitoring data and				
providing clinical interpretation/correlation to be helpful				
in making clinical decisions as part of daily clinical care.				
The integration and interpretation of multimodality	9 [8-9]	1		
neuromonitoring requires access to raw data for data				
manipulation outside of the devices on which data is				
measured, e.g., for pre-processing/cleaning,				
aggregation, integration with other data, computational				
analytics, and/or statistical analysis.*				ļ
The integration and interpretation of multimodality	9 [8-9]	1		
neuromonitoring data requires review of a variety of				
time-scales - from hours to days of data - in order to				

make clinically meaningful inferences from the				
information.				
The integration and interpretation of multimodality	9 [8-9]	1		
neuromonitoring requires specific skill or expertise to				
synthesize multiple data trends over time that reflect				
disease trajectory.				
The integration and interpretation of multimodality	7 [6-9]	3	18 (82)	1 (5)
neuromonitoring requires skill or expertise that is not				
routinely developed by any single fellowship training				
programs that exist currently.				
The integration and interpretation of multimodality	9 [8-9]	1		
neuromonitoring requires integration with both brain-				
specific data and systemic data traditionally measured				
during critical care (e.g., hemodynamic information).				
The integration and interpretation of multimodality	9 [8-9]	1		
neuromonitoring requires clinical context and that				
'clinical correlation' is a central component of this				
process.				
The application and maintenance of equipment and	8 [7-9]	2	18 (82)	0 (0)
technologies related to multimodality neuromonitoring				
is time intensive for a clinician independent of other				
clinical duties.		_		- (-)
The synthesis and interpretation of multiple	8 [7-9]	2	18 (82)	0 (0)
neuromonitoring data trends is time intensive for a				
clinician independent of other clinical duties.			4 (5)	47 (76)
Existing billing codes for other neurophysiologic	2.5 [1-4]	3	1 (5)	17 (76)
procedures such as continuous video EEG monitoring				
(e.g., CPT [®] 95720) of intraoperative monitoring (e.g.,				
multimedality neuromonitoring **				
Operationalizing MNM				
Provide for bedside users (e.g., clinical care team) an	8 [7_9]	1		
interface that facilitates an understanding of multiple	8[7-8]	T		
narameters in the context of a specific disease process				
Provide for bedside users (e.g. clinical care team) an	8 [7 5-8]	0.5		
interface that displays trend data on a single screen that	0[7.5 0]	0.5		
can be used to manipulate and explore data				
Enhance clinical confidence in our monitoring data by	8 [7-8 5]	15		
using software tools to identify or remove artifacts	0[, 0.0]	1.0		
within real-time monitoring data that limits clinical				
interpretation by bedside users (e.g., clinical care team).				
Identify necessary Information Technology (IT) or	8 [7-8]	1		
Clinical Engineering personnel to overcome				
technological hurdles that limit access to monitoring				
data at my institution.				
Invest in education for bedside users (e.g., clinical care	8 [8-9]	1		
team) focused on understanding the parameters being				
measured and why.				
Invest in education for bedside users (e.g., clinical care	8 [7-9]	2	17 (77)	2 (9)
team) focused on learning how to respond to				
monitoring data.				

Standardize who is monitored and by which	8 [7-8]	1		
technologies.	0[, 0]	-		
Develop clinical management algorithms based on	8 [6-8]	2	17 (77)	1 (5)
patterns within monitoring data that can be identified	0 [0 0]	-	_, (, , ,	- (0)
by bedside users (e.g., clinical care team)				
Identify physiologic thresholds and other findings during	7 [7-8]	1		
monitoring that would mandate clinical action or trigger				
clinical judgement.				
Access to a standardized lexicon of patterns that occur	7 [7-8]	1		
in and between physiologic variables associated with				
specific underlying biology or clinical relevance.				
Enlist staff and/or trainees to provide expertise in the	7 [7-8]	1		
technical and clinical aspects of our monitoring devices				
at all times (including nights or weekends).				
Staff member to act as a 'clinical champion' to	8 [7-9]	2	17 (77)	1 (5)
encourage the use of monitoring.			. ,	
Directly engage the multiple stakeholders that are	8 [7.5-8.5]	1		
involved in the day-to-day care for patients undergoing				
monitoring, including neurocritical care, neurosurgery,				
neurology and others.				
Schedule regularly held multidisciplinary case	8 [7-9]	2		
conferences to discuss relevant monitoring cases with				
others involved in day-to-day care for patients				
undergoing monitoring.				
Training Background				
Specific training or expertise is required to adequately	9 [8-9]	1		
prepare clinicians to understand and interpret				
multimodality neuromonitoring information.				
Clinical training programs in emergency medicine	3 [2-4]	2	0 (0)	19 (95)
provide a knowledge base that adequately prepares				
clinicians to understand and interpret multimodality				
neuromonitoring information. **				
Clinical training programs in specialty nursing provide a	3 [2-4.5]	2.5	0 (0)	19 (95)
knowledge base that adequately prepares clinicians to				
understand and interpret multimodality				
neuromonitoring information. **				
Education Format				
Hands-on workshops or seminars	7 [7-8]	1		
Clinical practice or bedside teaching	8 [7-9]	2	20 (91)	2 (9)
Development of a core curriculum	8 [6.5-9]	2.5	16 (73)	1 (5)
Supervised performance and demonstration of				
procedural competency	7 [6.5-8.5]	2	18 (82)	2 (9)

CPT = *Current Procedural Terminology*[®], *EEG* = *electroencephalography*, *GCS* = *Glasgow Coma Scale*, *ICU* = *intensive care unit*, *IQR* = *interquartile range*, *MNM* = *multimodality neuromonitoring*

Agreement was defined as a median Likert score of \geq 7 or \leq 3 while *consensus* was defined as > 70% within the lowest or highest tertile and an IQR difference \leq 1.75. Items achieving consensus during discussion-based round three must have a) agreement during round two plus b) at least 70% voting strong agreement and < 10% voting strong disagreement.

*Indicates items that lacked inter-round stability during Round 2

**Indicates items for which there was consensus disagreement

Supplemental Table 4: Areas of Agreement without Consensus

Clinical Considerations for Utility of MNM

Potential for harm related to placement of invasive neuromonitoring devices or devices with more than minimal risk relative to benefit

Time point within a specific disease course (e.g., number of days following an injury)

The institution's comfort level in the use of neuromonitoring

Case Presentations: Invasive Monitoring Only

Metabolic encephalopathy (e.g., severe hyperglycemia or hyponatremia) clinical or radiographic concern for cerebral edema who has an abnormal neurological exam but is able to follow commands (GCS 9-12)*

Requiring deep sedation, anesthesia, or paralytics for non-neurological reasons (e.g., ventilatory support) with no structural injury on imaging at-risk for unstable hemodynamics*

Severe acute respiratory failure (e.g., acute respiratory distress syndrome [ARDS]) requiring venovenous extracorporeal membrane oxygenation (VV-ECMO)*

Case Presentations: Invasive and/or Non-invasive Monitoring

Sinus thrombosis or posterior reversible encephalopathy syndrome (PRES) with cerebral edema at risk for herniation who is comatose (GCS 8 or less)

Following cardiac arrest with short downtime, no past medical history, and normal head CT who is comatose after rewarming (i.e., > 24 hours after arrest)

Following cardiac arrest with short downtime, no past medical history and clinical or radiographic concern for cerebral edema

Case Presentations: Non-invasive Monitoring Only

Aneurysmal subarachnoid hemorrhage with an abnormal neurological exam but able to follow commands (Hunt-Hess 3-4) after initial resuscitation and/or treatment of hydrocephalus

Hemispheric ischemic stroke with malignant edema either not yet committed to surgical decompression or following adequate surgical decompression?

Super-refractory status epilepticus requiring multiple anesthetic medications?

Infectious or presumed infectious encephalitis/meningitis who is comatose (GCS 8 or less) without evidence of seizures, hydrocephalus, or other causes of coma

Reversible cerebral vasoconstriction syndrome or other vasculopathy at risk for evolving ischemia who is comatose (GCS 8 or less)?

Following cardiac arrest with short downtime, no past medical history, and normal head CT who is comatose during targeted temperature management (i.e., within 24 hours of arrest)?

Following cardiac arrest with no past medical history and normal head CT who is comatose and develops clinical post-anoxic myoclonus early after injury?

Metabolic encephalopathy (e.g., severe hyperglycemia or hyponatremia) with clinical or radiographic concern for cerebral edema who is comatose (GCS 8 or less)?

Cytokine release syndrome-related encephalopathy (e.g., due to SARS-CoV-2 or CAR T-cell neurotoxicity syndrome) or other inflammatory condition with clinical or radiographic concern for cerebral edema who is comatose (GCS 8 or less)

Fulminant hepatic failure with clinical or radiographic concern for cerebral edema who is comatose (West Haven Stage 4)

Cardiopulmonary failure requiring veno-arterial extracorporeal membrane oxygenation (VA-ECMO)

Sepsis who is comatose (GCS 8 or less) due to underlying septic encephalopathy or shock

Genetic metabolic disorder with or without seizures at-risk for metabolic decompensation and global cerebral edema who is comatose (GCS 8 or less)?

Severe ARDS requiring VV-ECMO

Minimum Necessary Devices

Optimal Cerebral Perfusion Pressure (CPPopt)

Cerebrovascular Autoregulation

Quantitative EEG (qEEG)

Autonomic Function (e.g., heart rate variability) *

Minimum Necessary Access

Electronic Health Record capture of single measurement values, e.g., within flowsheet rows or tables

Ability to annotate neuromonitoring data remotely to indicate clinical events or other contextual data

Ability to access neuromonitoring data for use in other software packages by downloading from a hardware interface (e.g., bedside download of data through a USB drive)

Ability to access neuromonitoring data for use in other software packages through software or server-based interface (e.g., data is accessible from a server)

Ability to display therapeutic decision-making aids, decision support tools or diagnostic/management algorithms for clinical staff at bedside, e.g., interactive prompts or stepwise clinical guidance.

Ability to access neuromonitoring data in real-time for use in a secure cloud-based platform capable of deploying data analytic tools (e.g., machine learning algorithms).

Minimum Necessary Work

Existing billing codes for critical care (e.g., CPT[®] 99291 or 99292) adequately capture the work of multimodality neuromonitoring*

Operationalizing MNM

Enhance clinical confidence in our monitoring data by providing transparency for the methods used to derive calculations or summary statistics.

Provide remote access to monitoring data for members of the clinical care team.

Disseminate existing evidence-based data and consensus-based care protocols to bedside users (e.g., clinical care team).

Hire or enlist technologists, advanced practice providers and/or nursing educators to be available to provide expertise in the technical and clinical aspects of our monitoring devices at all times (including nights or weekends).

Institutional provision of adequate time and support for a dedicated staff member to perform clinical interpretation of real-time monitoring data (e.g., a neuromonitoring 'reader').

Daily communication of information obtained from monitoring was made available either through notes in the Electronic Health Record or by sending emails to the clinical care team (e.g., neuromonitoring 'reports').

A *centralized* expert reader through remote tele-health review of patients undergoing monitoring at my institution.

Develop a business plan that financially incentivizes my hospital to invest in necessary capital expenditures. Reimbursement strategy (e.g., a dedicated CPT[®] code for neuromonitoring) to support dedicated clinicians to

perform interpretation and reporting of monitoring data for use by clinical care teams in caring for patients with brain injuries.

Training Background

All clinical training programs for practitioners who will be taking care of brain injured patients should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring.

Only clinical training programs at centers that regularly use multimodality neuromonitoring should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring

An adequate knowledge base to understand and interpret multimodality neuromonitoring information does not require additional training in clinical neurophysiology or EEG regardless of primary specialty training*

An adequate knowledge base to understand and interpret multimodality neuromonitoring information does require additional training in clinical neurophysiology or EEG regardless of primary specialty training.

Education Format

Case-based learning

Multidisciplinary case conferences

Recognition through an online certification process supported through collaborative partners interested in advancing neuromonitoring

Recognition through a certification process supported through national societies (e.g., Neurocritical Care Society [NCS], American Clinical Neurophysiology Society [ACNS], or the American Society of Neurophysiologic Monitoring [ASNM]).

CAR = chimeric antigen receptor, CPT = Current Procedural Terminology[®], CT = computed tomography, EEG = electroencephalography, GCS = Glasgow Coma Scale, ICU = intensive care unit, IQR = interquartile range, MNM = multimodality neuromonitoring

*Indicates *dis*agreement with the item without consensus

Supplemental Table 5: Areas without Agreement

The perception of the medical team that a certain prognosis is inevitable

Age (either too young or too old)

Presence of additional organ dysfunction (e.g., stress cardiomyopathy or acute respiratory distress syndrome [ARDS])

Case Presentations: Invasive Monitoring Only

Aneurysmal subarachnoid hemorrhage who has an abnormal neurological exam but is able to follow commands (Hunt-Hess 3-4) after initial resuscitation and/or treatment of hydrocephalus?

Hemispheric ischemic stroke at-risk for malignant edema not yet committed to surgical decompression?

Hemispheric ischemic stroke with malignant edema following adequate surgical decompression?

Super-refractory status epilepticus requiring multiple anesthetic medications?

Infectious or presumed infectious encephalitis/meningitis who is comatose (GCS 8 or less) without evidence of seizures, hydrocephalus, or other causes of coma?

Reversible cerebral vasoconstriction syndrome or other vasculopathy at risk for evolving ischemia who is comatose (GCS 8 or less)?

Following cardiac arrest with short downtime, no past medical history, and normal head CT who is comatose during targeted temperature management (i.e., within 24 hours of arrest)?

Following cardiac arrest with no past medical history and normal head CT who is comatose and develops clinical post-anoxic myoclonus early after injury?

Metabolic encephalopathy (e.g., severe hyperglycemia or hyponatremia) clinical or radiographic concern for cerebral edema who is comatose (GCS 8 or less)?

Cytokine release syndrome-related encephalopathy (e.g., due to SARS-CoV-2 or CAR T-cell neurotoxicity syndrome) or other inflammatory condition clinical or radiographic concern for cerebral edema who is comatose (GCS 8 or less)

Fulminant hepatic failure clinical or radiographic concern for cerebral edema who is comatose (West Haven Stage 4)

Cardiopulmonary failure requiring veno-arterial extracorporeal membrane oxygenation (VA-ECMO)

Sepsis who is comatose (GCS 8 or less) due to underlying septic encephalopathy or shock

Genetic metabolic disorder with or without seizures at-risk for metabolic decompensation and global cerebral edema who is comatose (GCS 8 or less)?

Case Presentations: Invasive and/or Non-invasive Monitoring

Non-surgical traumatic brain injury who has an abnormal neurological exam but is able to follow commands (GCS 9-12) after initial resuscitation?

Surgical traumatic brain injury who has an abnormal neurological exam but is able to follow commands (GCS 9-12) after appropriate evacuation and/or decompression?

Supratentorial (lobar or basal ganglia) intracerebral hemorrhage +/- intraventricular extension who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

Non-surgical traumatic brain injury who has an abnormal neurological exam but is able to follow commands (GCS 9-12) after initial resuscitation with spinal cord injury or significant long bone fractures that limit motor examination and require early or urgent major surgery?

Case Presentations: Non-invasive Monitoring Only

Metabolic encephalopathy (e.g., severe hyperglycemia or hyponatremia) clinical or radiographic concern for cerebral edema who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

No structural injury on imaging and who requires deep sedation, anesthesia, or paralytics for non-neurological reasons (e.g., ventilatory support) and is at-risk for unstable hemodynamics?

Minimum Necessary Devices

Cardiac output (including associated measures of intravascular volume)

Jugular venous oxygen (SjvO2)

Regional oxygen saturation (rSO2) using near-infrared spectroscopy (NIRS) or other optical imaging technology Regional cerebral blood flow (rCBF)

Brain temperature

Brain water constant (K)

Cerebral microdialysis: lactate and pyruvate

Cerebral microdialysis: brain tissue glucose

Cerebral microdialysis: glutamate

Cerebral microdialysis: glycerol

Electrocorticography: single-wire or depth electrode

Electrocorticography: strip electrode

Full-band (DC or near-DC) EEG recordings

Processed EEG indices of anesthesia/sedation depth

Extended-duration (> 30 min) or frequent (> 1 daily) transcranial Doppler ultrasonography

Minimum Necessary Access

Ability to set alarms or thresholds to alert staff remotely, e.g., through push notifications or email

Minimum Necessary Work

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have clinical knowledge of brain physiology sufficient to use multimodality neuromonitoring data in making clinical decisions as part of daily clinical care.

I feel that the integration and interpretation of multimodality neuromonitoring data is part of neurocritical care and is NOT distinct from the work of either critical care or general clinical duties as it exists currently.

I feel that the integration and interpretation of multimodality neuromonitoring data is part of neurocritical care and would not be distinct from the work of either critical care or general clinical duties if a simplified user interface is provided for bedside users without expertise and/or experience.

Operationalizing MNM (no items unable to reach agreement or consensus)

Training Background

I feel that clinical training programs in the neurological specialties (e.g., neurocritical care or neurophysiology) provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.

I feel that clinical training programs in anesthesia and/or intensive care provide a knowledge base that... prepares clinicians to understand & interpret multimodality neuromonitoring information.

I feel that clinical training programs in neurosurgery provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information requires additional training in data management or health informatics.

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information requires additional training in bioengineering, signal analysis, or time-series analysis

Education Format

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through simulation or sim-based learning.

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through online, self-paced modules.

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through dedicated fellowship training.

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring should be recognized through formal board certification (e.g., through the United Council for Neurological Subspecialties or the American Board of Medical Specialties).

CAR = chimeric antigen receptor, CPT = Current Procedural Terminology[®], CT = computed tomography, EEG = electroencephalography, GCS = Glasgow Coma Scale, ICU = intensive care unit, IQR = interquartile range, MNM = multimodality neuromonitoring

* 'Continuous' is defined by data sampled no less frequently than every 6 hours. The majority of devices that fulfill this criterion are sampled more frequently, and there should be a preference for waveform or second-to-second data where applicable



Supplemental Figure 1: Context-specific Devices and Measurements

Bar graphs reflecting devices and measurements felt to be important for each context of use. Contexts were chosen to reflect secondary brain injury patterns and participants were asked to select any modalities that would be necessary to detect these pathophysiologies. Participants were instructed not to consider cost or local availability of devices and to assume that any and all devices were available to them for a given patient. The x-axis reflects the number of participants that selected each concept out of a total of 35. Items in orange achieved agreement, defined as selection by >2/3 of participants; those in gray did not meet the threshold for agreement. In some cases, there was agreement among pediatric specialists but not adult specialists. These included the use of regional oxygen saturation and cardiac output monitoring for brain tissue hypoxia; regional oxygen saturation and quantitative EEG for cerebral ischemia; end-tidal CO2 monitoring for acute coma or disorders of consciousness; cardiac output monitoring and core body temperature in post-cardiac arrest; arterial blood pressure and end-tidal CO2 monitoring for mitochondrial dysfunction and metabolic crisis; and both cEEG and extended-duration TCD monitoring for ICP or intracranial hypertension. In contrast, adult specialists were more likely to select invasive measurements including cerebral autoregulation metrics and optimum CPP estimation, brain tissue oxygen monitoring, and cerebral microdialysis. The proportion of adult vs pediatric participants selecting these devices and measurements was not statistically significant, however.

Supplemental Figure 2: Reporting Elements



Bar graphs reflecting reporting elements that participants would find important each day as the attending physician responsible for a patient undergoing clinical neuromonitoring in order to make

clinical decisions. The y-axis reflects the number of participants that selected each item. Items endorsed

by > 23 participants achieved the threshold for agreement.

The Practice of Clinical Multimodality Neuromonitoring: an eDelphi Consensus Statement

Problem & Rationale

'Neuromonitoring' refers to the use of any frequent (ideally, continuously) measure of brain physiology that can be performed at the bedside with a focus on detecting clinically-important events in realtime. This is distinct from 'neurodiagnostic' technologies such as radiological tests (CT, MRI) or tests ordered only infrequently or as-needed, such as somatosensory evoked potentials or serum-based biomarkers.

'Multimodality neuromonitoring' refers to the use of more than one data source to provide a more comprehensive assessment of the brain. This usually implies a higher level of complexity reserved for selected at-risk patients, typically in an ICU setting with limitations in neurological exam, such as coma.

The work that is involved in providing 'multimodality neuromonitoring' might encompass technical knowledge of devices that are only used to monitor specific patients, a familiarity with accessing or analyzing time-series data offline, and/or an ability to derive insights from physiologic data by looking at information across time.

However, there is no consensus for what constitutes the clinical PRACTICE of multimodality neuromonitoring. Specifically, gaps exist in defining the following:

- a. appropriate contexts of use or indications,
- b. minimum and/or necessary monitoring devices and measurements,
- c. minimum access requirements for clinical use (such as data integration and visualization),

d. work required to clearly differentiate from critical care or other related services (e.g. continuous video-EEG

reporting),

e. training necessary to provide clinically-meaningful interpretation

The clinical integration, interpretation, and reporting of multimodality neuromonitoring data has not crystallized as a distinct clinical service; questions exist as to whether it is a distinct service at all. This is in large part because there is no agreed-upon definition of 'multimodality neuromonitoring'.

This survey serves as Round 1 of an eDelphi process designed to provide consensus for these areas of uncertainty with goal of providing standards by which multimodality neuromonitoring may be distinguished as a unique diagnostic specialty.

Respondant Information

The eDelphi process is strictly anonymous and no identifying information should be shared. Below are questions that will be used to characterize the participant cohort.

1

What	is	your	training	background?
------	----	------	----------	-------------

- Neurology
- Pediatric Neurology
- Neurosurgery
- Internal Medicine
- Pediatrics
- Anesthesia
- Surgery
- Emergency Medicine
- Nursing
 Other

11/1/2022

Which is your c	urrent primary	practice?
-----------------	----------------	-----------

- Neurocritical Care
- Intensive Care
- Anesthesia
- Pediatric Critical Care
- Pediatrics
- Neurology
- Epilepsy and/or Clinical Neurophysiology
- Internal Medicine
- Neurosurgery
- Emergency Medicine
- Surgery



Other

3

Which population do you primarily care for?



Children

Neonates

Other

4

How many years have you been in independent practice?

- None (trainee)
- up to 5 years
- 6-10 years
- > 11 years

5

What is your academic research time allocation (%)?

- NA; I work in a community/private practice setting
- 100% of my time is dedicated to clincal duties
- <10% of my time is dedicated research time</p>
- 10-25% of my time dedicated research time
- 26-50% of my time is dedicated research time
- >50% of my time is protected for research

Other

Please select each of the physiologic measurement modalities below that you personally have used at some point in your career to provide or recommend care for patients:
N.B. This question assumes the routine use of clincally-standard non-invasive and arterial blood pressure cardiac telemetry, peripheral oxygen saturation , and core body temperature monitoring
Intracranial Pressure (ICP)
Cardiac Output (including associated measures of intravascular volume)
Cerebral Perfusion Pressure (CPP)
Optimal Cerebral Perfusion Pressure (CPPopt)
Cerebral Autoregulation
End-Tidal Capnography (ETCO2)
Brain Tissue Oxygen (PbtO2 or PtiO2)
Jugular Venous Oxygen (SjvO2)
Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
Regional Cerebral Blood Flow (rCBF)
Brain Temperature
Brain Water Constant (K)
Cerebral Microdialysis
Continuous Scalp EEG
Electrocorticography: Single-wire or Depth Electrode
Electrocorticography: Strip Electrode
Full-band (DC or near-DC) EEG Recordings
Quantitative EEG
Processed EEG Indices of Anesthesia/Sedation Depth

6

Quantitative Pupillometry

Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function (e.g. heart rate variability)

Contexts of Use: Clinical Considerations

Context of use is defined as the users, tasks, equipment, and the physical and social environments in which a system or service is used (ISO 9241-11:1998, 3.5, modified). In this case, we refer to the medical environment, e.g. the type of problem that a patient may have for which multimodality neuromonitoring might be useful or helpful.

7

How important is level of consciousness when determining the clinical utility of mulitmodality neuromonitoring for a patient?



8

How important is the underlying disease or diagnosis when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEA:	57 importa	nce 1	2	3			4	5 6	7 8 9 of MOST import
for	0 making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	Critical for making clinical management decision
1	2	3	4	5	6	7	8	9	
O	0	0	0	0	0	0	0	0	

How important is the potential risk for secondary brain injuries or secondary neurodeterioration when determining the clinical utility of multimodality neuromonitoring for a patient?

for	ST importa O maiking o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importation	5 6 ant, but not critical cal management decisions	7 for making c	8 Cri linical m	9 itical nanage	of MOST importance ment decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 〇				

10

How important is the potential for harm related to placement of neuromonitoring devices relative to their benefit when determining the clinical utility of multimodality neuromonitoring for a patient?

for	0 making	f limited	2 importa nanagen	3 Ince nent dec	isions	for mai	4 Importating clini	5 6 int, but not critical cal management decis	ions	7 8 9 of MOST importan Critical for making clinical management decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()		

11

How important is perceived prognosis when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEAS	S7 importa	nce 1	2	3			4	5 6	7	8	9 of MOST importance
for	O making o	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making o	Cri clinical m	itical nanagement decisions
1	2	3	4	5	6	7	8	9			

How important is age (either too young or too old) when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEA	S7 importa O maiking o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clini	5 int, but n cal mana	6 not critical agement deci	isions	7 for making o	8 Cr dinical r	9 nitical nanage	of MOST important	nce
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9							

13

How important are structural imaging findings when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEA	S7 importa O making i	nce 1 f <i>limited</i> clinical n	2 / importa nanagem	3 ince hent dec	isions	for mak	4 Importating clinit	5 6 ant, but not critical cal management decisions	7 for making cli	8 9 Critical nical manag	of MOST importance
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

14

How important is multimodality neuromonitoring in guiding individualized management decisions for a patient?

of LEA	\$7 importa	nce 1	2	3			4	5 6		7 8	9 of MOST importance
for	O making (f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but not crit cal managemen	<i>ical</i> nt decisions	for making clinical	ritical management decisions
1	2	3	4	5	6	7	8	9			
0	0	0	0	0	0	0	0	0			

15

How important is multimodality neuromonitoring in informing goals or thresholds for targeted management in a patient?

of LEAC	0 making	f limited	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importation	5 6 ant, but not critical cal management decisions	7 8 9 of MOST importance Critical for making clinical management decisions
1 ()	2 ()	3 ()	4	5 ()	6	7 ()	8	9 ()	

16

What other clinical considerations might inform the clinical utility of multimodality neuromonitoring for a patient?



Contexts of Use: Case Presentations

For all questions, please do not consider cost, relative contraindications such as coagulopathy, or barriers to the placement of intracranial devices. If you would not be primarily caring for a patient as described by the questions below, answer to the best of your ability based on your experience.

If your primary practice is PEDIATRIC, answer all questions below considering a child admitted to the Pediatric Intensive Care Unit for which there is a reasonable prognostic outlook and for whom all available brain monitoring - invasive and/or noninvasive as available at your institution - would be used.

If your primary practice involves ADULTS only, answer all questions below considering a middle-aged adult admitted to the Intensive Care Unit for which there is a reasonable prognostic outlook and for whom all available brain monitoring - invasive and/or noninvasive as available at your institution would be used.

17

How important is multimodality neuromonitoring in a patient presenting with:

a.) non-surgical traumatic brain injury

b.) who remains comatose (GCS 8 or less) after initial resuscitation?

of LEAS	T importa	nce 1	2	3			4	5	6	7	8	9	of MOST important
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but no cal manage	t critical ement decisions	for making	Cr clinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
2	0	0	0	0	0	0	0	0					

a.) surgical traumatic brain injury

b.) who remains comatose (GCS 8 or less) after appropriate evacuation and/or decompression?

of LEA	S7 importa O making (f <i>limited</i>	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Cri finical m	9 itical nanage	of MOST importance ment decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

19

How important is multimodality neuromonitoring in a patient presenting with:

a.) non-surgical traumatic brain injury

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-

12) after initial resuscitation?

ofLEA	57 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importa ting clini	int, but not critical cal management de	cisions	for making o	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

a.) surgical traumatic brain injury

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-

12) after appropriate evacutation and/or decompression?

of LEA	ST importa	nce 1	2	3			4	5 6	7 8	g of MOST imp
for	O making o	f <i>limited</i> clinical n	importa hanagen	nce hent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making clinic	Critical al management decis
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

21

How important is multimodality neuromonitoring in a patient presenting with:

a.) aneurysmal subarachnoid hemorrhage

b.) who remains comatose (Hunt-Hess 4-5) after initial resuscitation and/or treatment of hydrocephalus?

ofLEA	57 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importa ting clini	ant, but cal man	not critical agement decisio	ons	for making o	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	Õ	Ô	Ó	Ó	Ó	0	Ô	Ô						

a.) aneurysmal subarachnoid hemorrhage

b.) who has an abnormal neurological exam but is able to follow commands (Hunt-Hess 3-4) after initial resuscitation and/or treatment of hydrocephalus?

for	S7 importa O maiking o	f limited	2 /importa nanagen	3 Ince nent dec	isions	for mak	4 Importa	5 6 ant, but not critical cal management decisions	7 for making c	8 Cr linical n	9 itical nanage	of MOST importance ment decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

23

How important is multimodality neuromonitoring in a patient presenting with:

a.) aneurysmal subarachnoid hemorrhage

b.) who has developed vasospasm or vasospasm-associated delayed cerebral ischemia

c.) and who is comatose or ventilated on sedation?

d LEAS	17 importa	nce 1	2	3			4	5	6	7	8	9	of MOST important
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Import ing clini	ant, but not cal manage	t critical ement decisions	for making o	Cri finical n	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
2	0	0	0	0	0	\cap	0	\bigcirc					

How important is multimodality neuromonitoring in a patient presenting with: a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage without intraventricular hemorrhage

b.) who is comatose (GCS 8 or less)?

of LEA	S7 importa O malking o	f <i>limited</i>	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Cri finical m	9 itical nanage	of MOST importance
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

25

How important is multimodality neuromonitoring in a patient presenting with: a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage with intraventricular extension

b.) who is comatose (GCS 8 or less) after treatment of hydrocephalus?

ofLEA	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but no cal manag	ement decisions	for maki	(ng clinical	Critical manage	ment decisions
1	2 3 4 5 6			7	8	9							
0	0	0	0	0	0	0	0	0					

26

How important is multimodality neuromonitoring in a patient presenting with:

a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage +/-

intraventricular extension

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

for	57 importa O malking (nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 for making c	8 Cri finical m	9 itical nanager	of MOST importance
1	2 ()	3 ()	4	5	6 ()	7	8	9 ()				

27

How important is multimodality neuromonitoring in a patient presenting with: a.) hemispheric ischemic stroke at-risk for malignant edema not yet committed to surgical decompression?

ofLEA	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importa ing clini	int, but n cal mana	ot critical gement decisions	for making	Cri clinical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	Õ	Ó	0	Ô	Ó	0	Ô	Ô					

How important is multimodality neuromonitoring in a patient presenting with: a.) hemispheric ischemic stroke with malignant edema following adequate surgical decompression?

of LEA	57 importa O maiking o	f limited	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importation clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Crit linical m	9 of MOST import tical sanagement decision
1	2 ()	3 ()	4 ()	5 ()	6 ()	7 ()	8	9 ()			

29

How important is multimodality neuromonitoring in a patient presenting with: a.) super-refractory status epilepticus requiring multiple anesthetic medications?

of LEA	S7 importa O making	f limited	2 fimporta nanagen	3 ince nent dec	isions	for mak	4 Importa	5 ant, but a cal man	6 not critical agement decisions	7 for making o	8 Criti clinical ma	9 of MOST importance icol inagement decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				
3	10											

How important is multimodality neuromonitoring in a patient presenting with:

a.) infectious or presumed infectious encephalitis/meningitis

b.) who is comatose (GCS 8 or less) without evidence of seizures, hydrocephalus, or other causes of coma?

of LEAS	17 importa	nce 1	2	3			4	5 6	7	8	9 of MOST importanc
for	0 making	f <i>limited</i> clinical n	importa nanagen	ince hent dec	isions	for mak	Importa ting clini	int, but not critical cal management decision	s for making	Cr clinical n	itical nanagement decisions
1	2 ()	3 ()	4	5 ()	6 ()	7	8	9 ()			

How important is multimodality neuromonitoring in a patient presenting with: a.) sinus thrombosis or PRES with cerebral edema at risk for herniation b.) who is comatose (GCS 8 or less)?

for	0 maiking	nce 1 f limited clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 ant, but / cal mana	6 not critical agement decis	ions	7 for making o	8 Cri clinical m	9 tical nanager	of MOST importance ment decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						

32

How important is multimodality neuromonitoring in a patient presenting with:

- a.) RCVS or other vasculopathy at risk for evolving ischemia
- b.) who is comatose (GCS 8 or less)?

of LEAS	07 importa O maiking o	nce 1 f <i>limited</i> clinical n	2 / importa nanagen	3 Ince nent dec	isions	for mak	4 Importating clini	5 ant, but / cal mana	6 not critical agement dec	isions	7 for making o	8 Critinical n	9 itical nanage	of MOST importance
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						

33

How important is multimodality neuromonitoring in a patient presenting with:

- a.) following cardiac arrest
- b.) with short downtime, no past medical history, and normal CT
- c.) who is comatose during TTM (i.e. within 24 hours of arrest)?

of LEAS	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	0 making	f limited clinical n	importa nanagen	nce hent dec	isions	for mail	Importa ing clini	ant, but <i>no</i> cal manage	t critical ement decisions	for making o	Cri linical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

- a.) following cardiac arrest
- b.) with short downtime, no past medical history, and normal CT
- c.) who is comatose after rewarming (i.e. > 24 hours after arrest)?

ofiles	ST importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	Of limited importance for making clinical management decisions						Importa ing clini	int, but not critical cal management decisions	Critical for making clinical management decisio			
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

35

How important is multimodality neuromonitoring in a patient presenting with:

- a.) following cardiac arrest
- b.) with no past medical history and normal CT
- c.) who is comtaose and develops clinical post-anoxic myoclonus early after injury?

of LEA	\$7 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importan
for	Of limited importance for making clinical management decisions						Importa ing clini	ent, but not critical cal management decis	Critical sions for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

- a.) following cardiac arrest
- b.) with short downtime, no past medical history
- c.) and clinical or radiographic concern for cerebral edema?

of LEA	S7 importa O malking o	f <i>limited</i>	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 for making c	8 Cri linical m	9 itical nanage	of MOST importance ment decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7	8	9 ()				

37

How important is multimodality neuromonitoring in a patient presenting with:

- a.) metabolic encephalopathy (e.g. severe hyperglycemia or hyponatremia)
- b.) clinical or radiographic conern for cerebral edema
- c.) who is comatose (GCS 8 or less)?

of LEA	ST importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ent, but not critical cal management de	ecisions	Critical for making clinical management decisions			
1	2	3	4	5	6	7	8	9					
0	0	0	0	Ó	0	0	0	0					
38

How important is multimodality neuromonitoring in a patient presenting with:

a.) metabolic encephalopathy (e.g. severe hyperglycemia or hyponatremia)

b.) clinical or radiographic concern for cerebral edema

c.) who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

of LEA	S7 importa O malking o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 for making c	8 Cri linical m	9 of MOST importance tical nanagement decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

39

How important is multimodality neuromonitoring in a patient presenting with: a.) cytokine release syndrome-related encephalopathy (e.g. COVID-related, CAR T-cell

neurotoxicity syndrome) or other inflammatory condition

b.) clinical or radiographic concern for cerebral edema

c.) who is comatose (GCS 8 or less)

H LEA	57 importa	nce 1	2	3			4	5	6	7	8	9	of MOST important
for	0 making	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	ant, but / cal mana	not critical agement decisions	for makin	Cr g clinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
)	0	0	0	0	0	0	0	\bigcirc					

40

How important is multimodality neuromonitoring in a patient presenting with:

- a.) fulminant hepatic failure
- b.) clinical or radiographic concern for cerebral edema
- c.) who is comatose (West Haven Stage 4)

of LEA	57 importa O maiking o	f limited	2 /importa nanagen	3 Ince nent dec	isions	for mak	4 Importa	5 6 ant, but not critical cal management decisions	7 for making o	8 Critinical n	9 itical nanage	of MOST importance ment decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 〇				

41

How important is multimodality neuromonitoring in a patient presenting with: a.) cardiopulmonary failure requiring veno-arterial extracorporeal membrane oxygenation (VA-ECMO)

of LEA	\$7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa	nce nent dec	isions	for mak	Importa ting clini	int, but not critical cal management d	ecisions	for making o	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with: a.) sepsis

b.) who is comatose (GCS 8 or less) due to underlying septic encephalopathy or shock

ef LEA	S7 importa O malking o	f limited	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clinit	5 6 int, but not critical cal management decisions	7 for making c	8 Cri linical m	9 of MOST importance tical nanagement decisions
1 ()	2	3 ()	4	5 ()	6 ()	7 ()	8	e ()			

43

Please indicate other diagnoses or disease states for which multimodality neuromonitoring might be important for clinical decision-making. Be as specific as possible.

Contexts of Use: BRAIN TISSUE HYPOXIA

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage BRAIN TISSUE HYPOXIA.

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Select all that apply:

Intracranial Pressure (ICP

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial	Blood	Pressure	(ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: CEREBRAL ISCHEMIA

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage CEREBRAL ISCHEMIA.

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Select all that apply:

Intracranial Pressure (ICP		Intracranial	Pressure	(ICP)	í
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- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
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- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial	Blood	Pressure	(ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: AUTOREGULATORY DYSFUNCTION

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage AUTOREGULATORY DYSFUNCTION.

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Select all that apply:

Intracranial Pressure	e (ICP)	ĺ
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- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
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- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial	Blood	Pressure	(ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: METABOLIC CRISIS OR MITOCHONDRIAL DYSFUNCTION

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage METABOLIC CRISIS OR MITOCHONDRIAL DYSFUNCTION.

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Select all that apply:

Intracranial Pro	essure (ICP)
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- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial	Blood	Pressure	(ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: SEIZURES OR ICTAL-INTERICTAL CONTINUUM PATTERNS

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage SEIZURES OR ICTAL-INTERICTAL CONTINUUM PATTERNS.

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Select all that apply:

Intracranial Pressure	(ICP)	
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- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial B	lood Pressur	e (ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: SPREADING DEPOLARIZATIONS

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage SPREADING DEPOLARIZATIONS.

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Select all that apply:

Intracranial Pressure

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
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- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial	Blood	Pressure	(ABP)
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Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature

Contexts of Use: INTRACRANIAL HYPERTENSION OR HERNIATION

For each of the questions below, please select EACH of the physiologic measurements that you feel are useful to detect and optimally manage INTRACRANIAL HYPERTENSION OR HERNIATION.

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-	s	L	
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Select all that apply:

Intracranial Pressure

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
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- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)
- 11/1/2022 Autonomic Function (e.g. heart rate variability)

Arterial Blood Pressure (ABP)
Cardiac Telemetry (ECG)
Plethysmography (SpO2)
Continuous Core Body Temperature
51

What other secondary brain injury patterns or pathologies might you detect, predict, or gain clinically-relevant insight into by using multimodality neuromonitoring data?

Minimum Necessary Technology: Devices & Measurements

For each question, consider a hypothetical patient who requires the MOST comprehensive multimodality neuromonitoring available to you. Please do not consider specific brands or types of devices, rather focus on the measurement parameter itself.

How important are each of the following measurements to your clinical decision-making?

If a measurement modality is important only in conjunction with another measurement, BOTH should be rated as important. For example, if you feel cerebral autoregulation is extremely important and you measure it using rSO2, then rate both as extremely important even if you do not use rSO2 for anything else.

If you have no experience with using a particular measurement modality in clinical practice, simply answer to the best of your ability based on your experience and knowledge.

52

Intracranial Pressure (ICP)

for	or importa O making	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importation	5 6 ant, but not critical cal management decisions	7 8 9 of MOST importance Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

53

Cardiac Output (including associated measures of intravascular volume)

of LEAS	17 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management dee	cisions	for making c	Cri linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

54

Cerebral Perfusion Pressure (CPP)

	0	limited	Importo	-	- 1		Importa	at hut as	a coltical	-	0	9	of MOST importan
for n	naking c	linical m	anagem	nce ient deci	sions	for mak	ing clinic	al manag	ement decisions	for making	clinical n	nanage	ment decisions
	2	3	4	5	6	0	8	9					
60	0	\sim	0	0		\sim		U					
5	5												
Or	otima	l Cere	bral	Perfus	ion P	ressu	re (CP	Popt)					
								F V		_	_	_	
LEAS	T importan	ce 1	2	3	-		4	5	6	7	8	9	of MOST importan
for n	naking c	linical m	anagem	nce ient deci	sions	for mak	ing clinic	al manag	ement decisions	for making	clinical n	nanage	ment decisions
1	2	3	4	5	6	7	8	9					
)	0	0	0	0	0	0	0	0					
5	6												
5 Ce	6 Prebro	ovasci	ılar A	utore	gulat	ion							
5 Ce	6 erebro	ovasci	ular A	utore	gulat	ion							
5 Ce	6 erebro	ovasci	ular A	utore	gulat	ion	4	5	6	7	8	9	of MOST importan

57

End-Tidal Capnography (ETCO2)

LEAST importance 1	2	3		4	5	6		7	8	9	of MOST importan
Of <i>limite</i> for making clinical	d important manageme	ce nt decisions	for mak	Importa ting clinic	nt, but n cal manaj	ot critical gement dec	isions	for making	clinical m	ticol Ianagei	ment decisions
$) \bigcirc 0 \bigcirc 0$	4	5 6 O O	7	8	9						
58											
Brain Tissue	Oxyge	n (PbtO2	or Pti	O2)							
LEAST importance	2	3	_	4	5	6	_	7	8	9	of MOST importan
Of limite for making clinical	d important manageme	ce nt decisions	for mak	Importa ing clinic	nt, but <i>n</i> cal manaj	ot critical gement deci	isions	for making	clinical m	ticol ianagei	ment decisions
$) \bigcirc 0 \bigcirc 0$	4	00	0	8	0						
59											
Jugular Ven	ous Oxy	/gen (Sjv	O2)								
LEAST importance	2	3	2	4	5	6		7	8	9	of MOST importan
Of limite for making clinical	d important manageme	ce nt decisions	for mak	Importa ting clinic	nt, but n cal manaj	ot critical gement deci	isions	for making	Cri clinical m	tical Ianage	ment decisions
2 3	4	5 6	7	8	9						
	0	0 0	U	0	0						

Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRES) or other optical imaging technology

of LEA	S7 importa O maiking o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importation	5 6 Int, but not critical cal management decisions	7 for making o	8 Crit	9 of MOST importanc ticol anagement decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

61

Regional Cerebral Blood Flow (rCBF)

of LEA	S7 importa O making	f <i>limited</i>	2 importa nanagen	3 ince hent dec	isions	for mai	4 Importation	5 ant, but i cal man	6 not critical agement dec	isions	7 for making	8 Cr clinical n	9 itical nanage	of MOST importance
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6 Bi	52 rain Te	empe	rature	•										
of LEA	57 importa O making i	f limited	2 importa nanagen	3 ince hent dec	isions	for mal	4 Importation	5 ant, but / cal man	6 not critical agement dec	isions	7 for making	8 Cr clinical n	9 itical nanage	of MOST importance
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Brain Water Constant (K)

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64

Cerebral Microdialysis: Lactate & Pyruvate

	of LEAST importance	2	3		4	5	6		7	8	9	of MOST importance
	Of <i>limited</i> in for making clinical ma	nportar	nce ent decision	s for maki	mportan ng clinica	it, but n al mana	ot critici gement	al decisions	for making o	Cri dinical m	tical ianage	ment decisions
ŝ												



65

Cerebral Microdialysis: Brain Tissue Glucose

of LEAS	\$7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	/importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but no cal manag	erritical gement decisions	for making	Cri clinical m	itical nanage	ment decisions
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66

Cerebral Microdialysis: Glutamate

A LEAS	7 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importan
for n	O naking o	f <i>limited</i> clinical n	importa	nce ient deci	isions	for mak	Importa ting clinic	nt, but / cal mana	ot critical gement decis	ions	for making	Cr clinical r	itical nanage	ment decisions
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6	7													
Ce	erebra	al Mic	rodia	lysis:	Glyce	rol								
LEAS	7 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importan
-	0	f limited	importa	nce	100	2	Importa	nt, but /	not critical			G	itical	100000
or n	naking (cunical n	lanagem	ient deci	sions [for max	ung clinik	tai mana	igement decis	nons I	for making	ciinicai r	nanage	ment decisions
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10	\sim	\sim	\sim	\cup	\sim	\sim	\sim	<u> </u>						
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Co	ontinu	uous	Scalp	EEG										
LEAS	7 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importan
for n	Of	f limited	importa	nce ent deci	isions	for mak	Importa	nt, but /	not critical	lions	for making	Cr clinical r	itical nanage	ment decisions
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1	2	3	4	5	6	7	8	9						
)	0	0	0	0	0	0	0	0						

69

Electrocorticography: Single-wire or Depth Electrode

of LEAS	f importar	ce 1	2	3	ĺ.,		4	5	6		7	8	9	of MOST importa
for n	Of naking c	<i>limited</i> linical m	importa anagem	nce ient dec	isions	for mai	Importa ting clinit	int, but n cal mana	ot critical gement de	cisions	for making	Cr g clinical n	iticol nanager	nent decision
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7(2													
- 1														
Ele	ectro	cortico	ograp	iny: S	trip E	lectro	de							
LEAS	/ importar	ce 1	2	3	2		4	5	6		7	8	9	of MOST importa
for n	Of naking c	<i>limited</i> linical m	anagem	nce ient dec	isions	for mak	Importa ting clinit	int, but n cal mana	ot critical gement de	cisions	for making	Cr g clinical n	itical nanager	nent decision
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10	\sim	\bigcirc	\cup	\cup	\sim	0	\sim	\sim						
7	1													
Fu	II-bai	nd (D	C or r	near-[DC) E	EG Re	cordi	nas						
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R LEAS	7 importan	limited	2 importa	3 nce	_	_	4 Importa	5 ant, but n	6 ot critical		7	8	9 itical	of MOST importa
for n	naking c	linical m	anagem	ent dec	isions	for mail	ting clinit	cal mana	gement de	ecisions	for making	g clinical n	nanager	nent decision
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Quantitative EEG

LEAST importance 1 2 3	4 5 6	7 8 9 of MOST important
Of limited importance for making clinical management decisions	Important, but not critical for making clinical management decisions	Critical for making clinical management decisions
1 2 3 4 5 6	7 8 9	
	0 0 0	
73		
Processed EEG Indices of A	nesthesia/Sedation Depth	
ILEAST Importance 1 2 3	4 5 6	7 8 9 of MOST importan
for making clinical management decisions	for making clinical management decisions	for making clinical management decisions
1 2 3 4 5 6	7 8 9	
) 0 0 0 0 0 0	000	
74		
Quantitative Pupillometry		
LLAST importance 1 2 3	4 5 6	7 8 9 of MOST importan
Of limited importance	Important, but not critical	Critical
for making clinical management decisions	for making clinical management decisions	for making clinical management decisions
	/ 8 9	

Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography

of LEA	S7 importa O malking	nce 1 f <i>limited</i> clinical n	2 / importa nanagen	3 ance nent dec	isions	for mak	4 Importation	5 6 ant, but not critical cal management decisions	7 for making o	8 Cr finical r	9 itical nanage	of MOST importance
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

76

Autonomic Function (e.g. heart rate variability)

of LEAS	ST importan	sce 1	2	3	1		4	5	6		7	8	9	of MOST important	
for	Of making o	f limited clinical n	importa nanagen	nce hent dec	isions	for mak	Importa king clini	ant, but <i>r</i> cal mana	ot critical gement de	cisions	Critical for making clinical management decisions				
1	2	3	4	5	6	7	8	9							
		~													
7	7 rterial	Bloo	d Pre	SUIPA	(ARP	1									
ILLAS	17 importar	100	2	3	(101	,	4	5	6		7	8	9	of MOST importan	
for	Of making o	<i>limited</i> linical n	importa nanagen	ince hent dec	isions	for mak	Importa cing clini	ant, but / cal mana	<i>ot critical</i> gement de	cisions	for making	Cinical r	ritical manage	ment decisions	
1	2	3	4	5	6	7	8	9							
C	0	0	0	0	0	0	0	0							

Cardiac Telemetry (ECG)

of LEAS	0 making o	f limited	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clinit	5 int, but cal man	6 not critical agement decisions	7 8 9 of MOST imp Critical s for making clinical management decisi			
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7 Ce	9 ontini	uous	Core	Body	Temp	peratu	re						

of LEAST importance 1 2 3	4 5 6	7 8 9 of MOST importance
Of limited importance	Important, but not critical	Critical
for making clinical management decisions	for making clinical management decisions	for making clinical management decisions

1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0

80

What other neuromonitoring measurements do you consider to be important in clinical decision-making? Please be specific.

Minimum Necessary Technology: Access

How important are each of the following to the use of neuromonitoring data to make care decisions?

If you have no personal experience accessing neuromonitoring data as described below, answer to the best of your abilities based on your experience and knowledge.

81

Bedside visualization or display of a single, current (live) measurement value, e.g. a single numeric value displayed on a device at that moment in time visible in a patient care area

of LEA	S7 importa O malking o	f <i>limited</i>	2 /importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 8 for making clinical	9 of MOST importance ritical management decisions
1 ()	2 ()	3 ()	4	5 ()	6	7 ()	8	9 ()		

82

Bedside visualization or display of single measurement trended over time, e.g. a graph of a time-series displayed on a device visible in a patient care area

of LEAS	57 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importan
for	Of <i>limited</i> importance naking clinical management decisions				isions	for mak	Importa ing clini	ant, but <i>not critical</i> cal management d	for making c	Cri linical n	itical nanagei	ment decisions	
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Bedside visualization or display of multiple, current (live) measurement values together on the same screen, e.g. multiple numeric measurement values from different devices displayed on the same screen and visible in a patient care area

of LEA	57 importa O maiking o	f limited	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but <i>not critical</i> cal management decisions	7 for making c	8 Cri dinical m	9 of MOST importance itical nanagement decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

84

Bedside visualization or display of multiple measurements trended over time and aligned on the same screen, e.g. a graph of several time-series from different devices displayed on the same screen and visible in a patient care area

of LEA	S7 importa O malking	nce 1 f limited clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Crit linical m	9 tical anage	of MOST importance
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

85

Access to data with high temporal resolution (1 or more data points every minute) including clinically-standard data such as heart rate, arterial blood pressure in addition to neuromonitoring-specific data

of LEA	ST importa	nce 1	2	3			4	5 6	7 8 9 of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince hent dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
Access to data at waveform resolution, such as ECG waveforms, arterial blood pressure or intracranial pressure waveforms, or EEG signals

of LEA	S7 importa O malking i	nce 1 f <i>limited</i> clinical r	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importation	5 ant, but n ical mana	6 at critical gement de	cisions	7 for making	8 Critical m	9 ticol tanager	of MOST importan	
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()							

87

Electronic Health Record capture of single measurement values, e.g. within flowsheet rows or tables

tor making clinical management decisions 1 of making clinical management decisions	for making clinical management decisions
1 2 3 4 5 6 7 8 9 O O O O O O O O	

88

Electronic Health Record display (in a table or graph) of multiple different measurement values together on a single panel, tab, or screen

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importan
for	0 making (f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not criti cal managemen	cal t decisions	for making cl	Cri inical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Ability to manipulate data visualization or display AT BEDSIDE, e.g. zooming in or out (time scaling), scrolling back and forth in time, or selecting which neuromonitoring measurements to display

of LEA	S7 importa O maiking o	f <i>limited</i>	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clini	5 6 ant, but <i>not critical</i> cal management decisions	7 for making c	8 Critinical m	9 of MOST importa itical nanagement decision
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

90

Ability to annotate neuromonitoring data AT BEDSIDE to indicate clinical events or other contextural data

of LEAC	97 importa O malking o	f limited	2 importanagen	3 Ince nent dec	isions	for mai	4 Importation	5 ant, but cal man	6 not critical agement decis	sions	7 for making c	8 Cri linical m	9 ticol ianage	of MOST importance ment decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						
9	1													

Ability to display neuromonitoring data AT BEDSIDE linked with annotations to indicate clinical events or other contextural data

of LEAS	Timporta	nce 1	2	3			4	5 6	7 8 9 of MOST important
for	0 making o	f <i>limited</i> clinical n	importa nanagen	ince hent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisio	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

Ability to display neuromonitoring data AT BEDSIDE linked with Electronic Health Record information, e.g. laboratory values or medication administration information

for	O making o	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	for making o	Cri linical m	itical nanager	nent decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

93

Ability to visualize or display neuromonitoring data in real-time REMOTELY (from a separate reading room or from home)

of LEA	f (EAST importance 1 2 3 Of <i>limited</i> importance for making clinical management decisions				for mak	4 Importating clinit	5 ant, but / cal mana	6 not critical agement decisions	7 for making	8 Cri clinical m	9 itical nanager	of MOST importance	
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9					
ç	94												

Ability to manipulate and review displayed neuromonitoring data in real-time REMOTELY (from a separate reading room or from home), e.g. choosing specific neuromonitoring measurements to display or zooming in or out of the data

of LEAS	17 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O malking	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making o	Cr linical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

Ability to annotate neuromonitoring data REMOTELY to indicate clinical events or other contextural data

of LEAC	0 making	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 8 9 of MOST importance Critical for making clinical management decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()	

96

Ability to display neuromonitoring data REMOTELY linked with bedside annotations that indicate clinical events or other contextural data

of LEA	S7 importa O making o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 8 for making clinical	9 of MOST importance initical management decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()		

97

Ability to display neuromonitoring data REMOTELY linked with Electronic Health Record information, e.g. laboratory values or medication administration information

of LEAS	S7 importa	nce 1	2	3			4	5 6	7 8 9 of MOST important
for	O making o	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

Ability to access neuromonitoring data for use in other software packages (e.g. Excel or R) by downloading from a hardware interface (e.g. bedside download of data through a USB drive)

of LEAST	7 importa Of naking o	f limited	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importation	5 6 ant, but not critical cal management decisions	7 8 9 of MOST importance Critical for making clinical management decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7	8	9 ()	

99

Ability to access neuromonitoring data for use in other software packages (e.g. Excel or R) through software or server-based interface, e.g. data is accessible from a server

for	57 importa O making	f limited	2 / importa nanagen	3 ince hent dec	isions	for mai	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making o	8 Cri finical m	9 itical nanage	of MOST importance ment decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

100

Ability to set alarms or thresholds to alert staff AT BEDSIDE, e.g. via flashing colors or alarm sounds

of LEAST	importar	sce 1	2	3			4	5 6	7	8 9	of MOST importance
for m	Of aking o	<i>limited</i> dinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making clin	Critical nical manage	ment decisions
1	2	3	4	5	6	7	8	9			

Ability to set alarms or thresholds to alert staff REMOTELY, e.g. through push notifications or email

of LEA	S7 importa O maiking o	f limited	2 / importa nanagen	3 ince nent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making o	8 Critinical n	9 itical nanage	of MOST importance
1 ()	2 ()	3 ()	4	5 ()	6	7 ()	8	9 〇				

102

What other technologies or accessibility options do you find important in clinical decision-making? Please be specific.



Minimum Necessary Work: Open-Ended Questions

103

What criterion or criteria would you use to distinguish 'multimodality neuromonitoring' from the work of critical care, the work of interpreting continuous video-EEG, or general clinical duties? What, if anything, makes 'multimodality neuromonitoring' distinct?

104

In your view, how can multimodality neuromonitoring data best be operationalized in clinical practice on a day-to-day basis right now? How can multimodality neuromonitoring best be made usable or actionable at your institution? Imaginge you are talking care of a patient with severe brain injury. Just before walking into rounds, you are provided a summary report of your patient's neuromonitoring data. What information would you find helpful from such a report?

Minimum Necessary Work: Agree or Disagree

For the following questions, indiate the level of agreement about the following statements.

106

I feel that most intensivists staffing an ICU and caring for patients with brain injuries are able to adequately INTEGRATE AND INTERPRET multimodality neuromonitoring data as part of daily clinical care in order to make management decisions.

strong	y DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGRE
		Disa	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

107

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have adequate TIME to fully review all available multimodality neuromonitoring data as part of daily clinical care.

strong	y DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGAEE
		Dis	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have all the necessary TECHNOLOGY to integrate and interpret multimodality neuromonitoring data as part of daily clinical care.

strong	y DISAGRE	Disa	2 agree	3		N	4 either A	5 6 Agree nor Disagree	7 8 9 strongly AGRI Agree
1 ()	2 ()	3 ()	4	5 ()	6 ()	7	8	9 ()	

109

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have TECHNICAL KNOWLEDGE sufficient to troubleshoot device errors and to identify artifactual or erroneous multimodality neuromonitoring data.

strong	y DISAGRE	t 1 Disa	2 agree	3		N	4 either /	5 Agree no	6 or Disagree	7	8 Agree	9	strongly AGREE
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9					

110

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have CLINCAL KNOWLEDGE of brain physiology sufficient to use multimodality neuromonitoring data in making clinical decisions as part of daily clinical care.

strong	y DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGREE
		Disa	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	

I feel most intensivists staffing an ICU and caring for patients with brain injuries would find regularly written reports summarizing multimodality neuromonitoring data and providing clinical interpretation/correlation to be helpful in making clinical decisions as part of daily clinical care.

strong	y DISAGRE	e 1 Disa	2 agree	3		N	4 either A	5 Agree nor	6 Disagree	7 8 9 strongly AGREE Agree
1	2 ()	3 ()	4	5 ()	6	7	8	9 ()		

112

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires access to raw data for data manipulation outside of the devices on which data is measured, e.g. for pre-processing/cleaning, aggregation, integration with other data, computational analytics, and/or statistical analysis.

DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGREE
	Disa	agree			N	either A	Agree nor Disagree	Agree
2	3	4	5	6	7	8	9	
	2	DISAGAEE 1 Disa 2 3	DISAGATE 1 2 Disagree 2 3 4	DISAGAGE 1 2 3 Disagree 2 3 4 5	Disagree Disagree 2 3 4 5 6	DISAGAGE 1 2 3 Disagree No 2 3 4 5 6 7	2 3 4 5 6 7 8	DISAGAGE 1 2 3 4 5 6 Disagree Neither Agree nor Disagree 2 3 4 5 6 7 8 9

113

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring data requires review of a variety of time-scales - from hours to days of data - in order to make clinically-meaningful inferences from the information.

strongly	DISAGREE	1	2	3			4	5 6	7 8 9 strongly AGREE
		Disa	agree			N	either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	

Please enter any additional comments about the work required for multimodality neuromonitoring.

Training Standards: Open-Ended Questions

115

What training background is best suited to understand and make clinicallymeaningful inferences from multimodality neuromonitoring data?

116

What core concepts are required to understand and make clinically-meaningful inferences from multimodality neuromonitoring data? What educational format is best to train clinicians to understand and make clinicallymeaningful inferences from multimodality neuromonitoring data?

Training Standards: Agree or Disagree

For the following questions, indiate the level of agreement about the following statements.

118

I feel that specific training or expertise is required to best understand and interpret multimodality neuromonitoring information.

strong	y DISAGAE	1	2	3			4	5 6		7 8 9 strongly	AGREE			
	Disagree					N	either /	Agree nor Disag	ree	Agree				
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

119

I feel that clinical training programs in the neurological specialties provide a knowledge base that best allows clinicians to understand and interpret multimodality neuromonitoring information.

	Disagree						either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

I feel that clinical training programs in intensive care provide a knowledge base that best allows clinicians to understand and interpret multimodality neuromonitoring information.

strong	Y DISAGRE	Disa	2 agree	3		N	4 either A	5 6 Agree nor Disagree	7 8 9 strongly AGREE Agree
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()	

121

I feel that ALL clinical training programs for practitioners who will be taking care of brain injured patients should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring.

strong	V DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGREE
		Disa	agree			N	either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

122

I feel that ONLY clinical training programs at centers that regularly use multimodality neuromonitoring should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring.

strong	V DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGREE
		Disa	agree			N	either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	

120

Please enter any additional comments about multimodality neuromonitoring training standards.

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The Practice of Clinical Multimodality Neuromonitoring: an eDelphi Consensus Statement

* Required

Problem & Rationale

This survey serves as **Round 2** of an eDelphi process designed to provide consensus for areas of uncertainty with goal of providing standards by which multimodality neuromonitoring may be distinguished as a unique diagnostic specialty.

Round 2 will be used to quantify agreement and consensus and <u>does not include open-ended</u> <u>questions</u>. All responses from Round 1 were reviewed and incorporated as new questions which were added to appropriate sections throughout the survey. For previously answered questions, summary statistics are provided from Round 1 to incorporate into your responses in this Round.

By way of reminder, 'neuromonitoring' refers to the use of any frequent (ideally *continuously*) measure of brain physiology that can be performed at the bedside with a focus on detecting clinicallyimportant events in real-time. This is distinct from 'neurodiagnostic' technologies such as radiological tests (CT, MRI) or tests ordered only infrequently or as-needed, such as somatosensory evoked potentials or serum-based biomarkers.

'Multimodality neuromonitoring' refers to the use of *more than one data source* to provide a comprehensive assessment of the brain. This usually implies a higher level of complexity reserved for selected at-risk patients, typically in an ICU setting with limitations in neurological exam, such as coma.

Respondent Information

The eDelphi process is strictly anonymous and no identifying information should be shared.

You will find the same questions answered during Round 1 which will serve to compare both Rounds for consistency.

1

Please indicate if you previously completed Round 1: *

🔿 No

🔵 Yes





- Neurology
 Pediatric Neurology
 Neurosurgery
 Internal Medicine
 Pediatrics
 Anesthesia
 Surgery
- Emergency Medicine
- O Nursing



3	Ro	ound	11				
Which is your current primary practice? (select all that apply)	Neurocritical Care Neurosurgery Epilepsy and/or Clinical. Pediatric Critical Care Intensive Care Neurohospitalist Neurology Surgery Emergency Medicine Internal Medicine Pediatrics Anesthesia		3 2 2 2 5	10	15	20	22
Neurocritical Care							
Intensive Care							
Anesthesia							
Pediatric Critical Care							
Pediatrics							
Neurology							
Epilepsy and/or Clinical Neurophysiology							
Internal Medicine							

Neurosurgery

Emergency Medicine

Surgery

......

Other



Which population do you pr	imarily care for?
(select all that apply)	

Adults	
Children	
Neonates	
1	
Other	

How many years have you been in independent practice?



None (trainee)

O up to 5 years

6-10 years

> 11 years

What is your academic research time allocation (%)?



- NA; I work in a community/private practice setting
- 100% of my time is dedicated to clinical duties
- <10% of my time is dedicated research time</p>
- 10-25% of my time dedicated research time
- 26-50% of my time is dedicated research time
- >50% of my time is protected for research

Other

Please select each of the physiologic measurement modalities below that you personally have used at some point in your career to provide or recommend care for patients:



N.B. This guestion assumes the routine use of clinically-standard non-invasive and arterial blood



11/1/2022 Regional Cerebral Blood Flow (rCBF)

Brain Temperature
Brain Water Constant (K)
Cerebral Microdialysis
Continuous Scalp EEG
Electrocorticography: Single-wire or Depth Electrode
Electrocorticography: Strip Electrode
Full-band (DC or near-DC) EEG Recordings
Quantitative EEG
Processed EEG Indices of Anesthesia/Sedation Depth
Quantitative Pupillometry
Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function (e.g. heart rate variability)

Contexts of Use: Clinical Considerations

Context of use is defined as the users, tasks, equipment, and the physical and social environments in which a system or service is used (ISO 9241-11:1998, 3.5, modified). In this case, we refer to the medical environment, e.g. the type of problem that a patient may have for which multimodality neuromonitoring might be useful or helpful.

8

How important is level of consciousness when determining the clinical utility of mulitmodality neuromonitoring for a patient?

Round 1: Median [IQR] 8 [7-9]



New Question

How important are confounding factors that may cloud the neurological examination when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	0 making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management d	ecisions	for making o	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is the underlying disease or diagnosis when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 7 [7-8]

for	0 making	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making c	Cri linical m	itical nanager	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

11

New Question

How important is the presence of additional organ dysfunction (e.g. stress cardiomyopathy or acute respiratory distress syndrome [ARDS]) when determining the clinical utility of multimodality neuromonitoring for a patient?

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f limited clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ent, but not critico cal management	decisions	for making c	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
Ò	Õ	Õ	Ó	Õ	Õ	Ó	Õ	Õ					

How important is the potential risk for secondary brain injuries or secondary neurodeterioration when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 8.5 [8-9]

for	O making (f <i>limited</i> clinical n	importa nanagen	nce hent dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	for making clinic	Critical cal management decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

13

New Question

How important is a desire to understand the pathophysiology underlying brain dysfunction (e.g. diffuse vs focal injury processes) when determining the clinical utility of multimodality neuromonitoring?

of LEA	\$7 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince hent dec	isions	for mak	Importa ing clini	int, but n cal mana	ot critical gement decision	ts for i	making o	Cri linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

New Question

How important is the time point within a specific disease course (e.g. the number of days following an injury) when determining the clinical utility of multimodality neuromonitoring?



15

How important is the potential for harm related to placement of invasive neuromonitoring devices or neuromonitoring devices with more than minimal risk relative to their benefit when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 7 [6-9]

of LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importation in the second seco	ant, but / cal mana	ot critical gement decisions	for making c	Cri linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

New Question

How important is your institution's comfort level in the use of neuromonitoring when determining the clinical utility of multimodality neuromonitoring for a patient?



17

How important is the perception of the medical team that a certain prognosis is inevitable when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 6 [5.25-7]

N.B. this question does not refer to limiting or withdrawing care, but rather the perception that neuromonitoring will make no impact on a perceived inevitable outcome

of LEAS	\$7 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importan
for	O making o	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	Critical s for making clinical management decisions
1	2	3	4	5	6	7	8	9	
Ċ	Ō	0	0	Ô	Ó	0	Ô	Ó	

How important is age (either too young or too old) when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 5 [3-6]

of LEA	17 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	s for making o	Cri dinical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

19

How important are structural imaging findings when determining the clinical utility of multimodality neuromonitoring for a patient?

Round 1: Median [IQR] 7 [6-7.75]

of LEA	\$7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but not cal manage	critical ment decisions	for making o	Crit linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in guiding individualized management decisions for a patient?

Round 1: Median [IQR] 8 [7-8]

of LEA	\$7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	nce nent dec	isions	for mak	Importa ing clini	int, but not o cal managen	critical nent decisions	for making c	Cri linical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

21

How important is multimodality neuromonitoring in informing goals or thresholds for targeted management in a patient?

Round 1: Median [IQR] 8 [7-8]

of LEA	57 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ding clini	ant, but / cal mana	not criti agemen	cal t decisions	for makin	Cinical I	nitical manage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

New Question

How important is multimodality neuromonitoring in *abstaining from* or *de-escalating* a potential therapy or treatment that might cause harm?

of LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but n cal mana	ot critical gement decisions	for making c	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Contexts of Use: Case Presentations

For all questions, please do not consider cost, relative contraindications such as coagulopathy, or barriers to the placement of intracranial devices. If you would not be primarily caring for a patient as described by the questions below, answer to the best of your ability based on your experience.

If your primary practice is PEDIATRIC, answer all questions below considering a child admitted to the Pediatric Intensive Care Unit for which there is a reasonable prognostic outlook and for whom all available brain monitoring would be used with a <u>focus on invasive neuromonitoring devices or</u> <u>neuromonitoring devices with more than minimal risk</u>.

If your primary practice involves ADULTS only, answer all questions below considering a middle-aged adult admitted to the Intensive Care Unit for which there is a reasonable prognostic outlook and for whom all available brain monitoring would be used with a <u>focus on invasive neuromonitoring devices</u> or neuromonitoring devices with more than minimal risk.

23

How important is multimodality neuromonitoring in a patient presenting with:

a.) non-surgical traumatic brain injury

b.) who remains comatose (GCS 8 or less) after initial resuscitation?

Round 1: Median [IQR] 9 [8-9]

of LEA	S7 importa	nce 1	2	3			4	5 6	5	7	8	9	of MOST importance
for	0 making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importating clini	int, but not cr cal managem	itical ent decisions	for making o	Crit linical m	ticol anagei	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with:

a.) non-surgical traumatic brain injury

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-

12) after initial resuscitation?

Round 1: Median [IQR] 6 [3.25-6]

of LEA	\$7 importa	nce 1	2	3			4	5 6	7	8 9 of MOST importan
for	O making (f <i>limited</i> clinical n	/importa nanagen	ince nent dec	isions	for mak	Importating clini	ant, but not critical cal management decisio	ons for making cli	Critical nical management decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

25

New Question

How important is multimodality neuromonitoring in a patient presenting with:

a.) non-surgical traumatic brain injury

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-

12) after initial resuscitation

c.) with spinal cord injury or significant long bone fractures that limit motor examination and require early or urgent major surgery?

of LEAS	17 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	
How important is multimodality neuromonitoring in a patient presenting with:

a.) surgical traumatic brain injury

b.) who remains comatose (GCS 8 or less) after appropriate evacuation and/or decompression?

Round 1: Median [IQR] 8 [7-9]

of LEAS	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	/ importa nanagen	ince hent dec	isions	for mak	Importa ing clini	nt, but not critical cal management decisio	ns for m	aking cl	Cri linical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

27

How important is multimodality neuromonitoring in a patient presenting with:

a.) surgical traumatic brain injury

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-

12) after appropriate evacuation and/or decompression?

Round 1: Median [IQR] 5 [4-6]

of LEAS	S7 importa	nce 1	2	3			4	5 6	7	8	9	of MOST important
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importating clini	ent, but not critical cal management decisions	for making cli	Cri nical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

How important is multimodality neuromonitoring in a patient presenting with:

a.) aneurysmal subarachnoid hemorrhage

b.) who remains comatose (Hunt-Hess 4-5) after initial resuscitation and/or treatment of hydrocephalus?

Round 1: Median [IQR] 8.5 [7-9]

of LEA	\$7 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	nt, but not critical cal management decision	s for maki	Cing clinical i	ritical manage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

29

How important is multimodality neuromonitoring in a patient presenting with:

a.) aneurysmal subarachnoid hemorrhage

b.) who has an abnormal neurological exam but is able to follow commands (Hunt-Hess 3-4) after initial resuscitation and/or treatment of hydrocephalus?

Round 1: Median [IQR] 6 [5-7]

of LEA	S7 importa	nce 1	2	3			4	5 6	7 8	9 of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importating clini	int, but not critical cal management decisions	for making clinica	Critical al management decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

How important is multimodality neuromonitoring in a patient presenting with:

a.) aneurysmal subarachnoid hemorrhage

b.) who has developed vasospasm or vasospasm-associated delayed cerebral ischemia

c.) and who is comatose or ventilated on sedation?

Round	1:	Median	[IQR]	9	[8-9]	

of LEAS	\$7 importa	nce 1	2	3			4	5 6	7 8	9 of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	nce hent dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	Ci for making clinical r	itical nanagement decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

31

How important is multimodality neuromonitoring in a patient presenting with: a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage without intraventricular hemorrhage

b.) who is comatose (GCS 8 or less)?

Round 1: Median [IQR] 7 [6-9]

of LEAS	T importa	nce 1	2	3	3		4	5 6	7 8 9 d	MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	Critical for making clinical management	nt decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

How important is multimodality neuromonitoring in a patient presenting with: a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage with intraventricular extension b.) who is comatose (GCS 8 or less) after treatment of hydrocephalus?

Round 1: Median [IQR] 7 [6-9]

of LEAS	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	int, but not critical cal management decisio	ns for ma	iking clir	Crit nical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

33

How important is multimodality neuromonitoring in a patient presenting with:

a.) supratentorial (lobar or basal ganglia) intracerebral hemorrhage +/-

intraventricular extension

b.) who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

Round 1: Median [IQR] 5 [4-6]

of LEAS	17 importa	nce 1	2	3			4	5 6	7 8	9 of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	Cri for making clinical m	tical nanagement decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

How important is multimodality neuromonitoring in a patient presenting with: a.) hemispheric ischemic stroke at-risk for malignant edema not yet committed to surgical decompression?

Round 1: Median [IQR] 5 [3-7.75]

of LEA	57 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	for making c	Cri linical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

35

How important is multimodality neuromonitoring in a patient presenting with: a.) hemispheric ischemic stroke with malignant edema following adequate surgical decompression?

Round 1: Median [IQR] 5 [3.25-7]

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	0 making	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but not critical ical management dec	for making c	Cri linical m	tical ianage	ment decisions	
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with: a.) super-refractory status epilepticus requiring multiple anesthetic medications?

Round 1: Median [IQR] 8 [5.25-9]

of LEA	\$7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making d	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mai	Importa ting clini	nt, but not critical cal management dec	isions	for making c	Cri linical m	ticol nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

37

How important is multimodality neuromonitoring in a patient presenting with: a.) infectious or presumed infectious encephalitis/meningitis b.) who is comatose (GCS 8 or less) without evidence of seizures, hydrocephalus, or other causes of coma?

Round 1: Median [IQR] 6 [5-8]

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	0 making	f <i>limited</i> clinical r	l importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but not critico cal management o	decisions	for making c	Cri finical m	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with: a.) sinus thrombosis or PRES with cerebral edema at risk for herniation b.) who is comatose (GCS 8 or less)?

Round 1: Median [IQR] 7.5 [6-9]

of LEA	57 importa O malking o	nce 1 f <i>limited</i> clinical n	2 importanagen	3 ince nent dec	isions	for mak	4 Importa ing clini	5 6 int, but not critical cal management decisions	7 for making cl	8 Cri linical m	9 tical nanage	of MOST importance
1 ()	2	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

39

How important is multimodality neuromonitoring in a patient presenting with: a.) RCVS or other vasculopathy at risk for evolving ischemia b.) who is comatose (GCS 8 or less)?

Round 1: Median [IQR] 6 [5.25-8.75]

of LEAS	57 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but <i>not critico</i> cal management d	/ lecisions	for making c	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with:

a.) following cardiac arrest

b.) with short downtime, no past medical history, and normal CT

c.) who is comatose during TTM (i.e. within 24 hours of arrest)?

Round 1: Median [IQR] 6 [5-8]



How important is multimodality neuromonitoring in a patient presenting with:

a.) following cardiac arrest

b.) with short downtime, no past medical history, and normal CT

c.) who is comatose after rewarming (i.e. > 24 hours after arrest)?

Round 1: Median [IQR] 7 [5.25-8.75]

of LEAS	ST importa	nce 1	2	3			4	5 6	7 8 9 of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ent, but not critical cal management decisions	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

How important is multimodality neuromonitoring in a patient presenting with:

- a.) following cardiac arrest
- b.) with no past medical history and normal CT
- c.) who is comatose and develops clinical post-anoxic myoclonus early after injury?

Round 1: Median [IQR] 7 [6-8]

of LEA	17 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince hent dec	isions	for mak	Importa ting clini	nt, but not critical cal management decisions	for making cli	Cri inical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

43

How important is multimodality neuromonitoring in a patient presenting with:

- a.) following cardiac arrest
- b.) with short downtime, no past medical history
- c.) and clinical or radiographic concern for cerebral edema?

Round 1: Median [IQR] 6 [5-8]

of LEAS	Timporta	nce 1	2	3			4	5 6	7	8 9	of MOST importance
for	Of making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ent, but not critical cal management decisions	for making clinic	Criticol cal manage	ment decisions
1	2	3	4	5	6	7	8	9			
0	0	0	0	0	0	0	0	0			

New Question

How important is multimodality neuromonitoring in a patient presenting with:

a.) no structural injury on imaging

 b.) and who requires deep sedation, anesthesia, or paralytics for non-neurological reasons (e.g. ventilatory support)

c.) and is at-risk for unstable hemodynamics?

of LEA	S7 importa O malking o	f limited	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clinit	5 6 ant, but not critical cal management decisions	7 for making o	8 Criti clinical ma	9 of MOST importanc icol anagement decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 〇			

45

How important is multimodality neuromonitoring in a patient presenting with: a.) toxic-metabolic encephalopathy (e.g. severe hyperglycemia or hyponatremia) b.) clinical or radiographic concern for cerebral edema

c.) who is comatose (GCS 8 or less)?

Round 1: Median [IQR] 6 [5-8]

of LEA	ST importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but not critical cal management d	ecisions	for making c	Cri linical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with:

a.) toxic-metabolic encephalopathy (e.g. severe hyperglycemia or hyponatremia)

b.) clinical or radiographic concern for cerebral edema

c.) who has an abnormal neurological exam but is able to follow commands (GCS 9-12)?

R	ound	1: Me	edian	[IQR]	5 [3	3-6]								
of LEA	57 importa O malking o	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince nent dec	isions	for mak	4 Importa ing clini	5 int, but r cal mana	6 lot critical gement deci	sions	7 for making o	8 Cri dinical m	9 tical sanage	of MOST importance
1	2 ()	3 ()	4	5 ()	6 ()	7	8 ()	9 ()						

47

New Question

How important is multimodality neuromonitoring in a patient presenting with:

a.) genetic metabolic disorder with or without seizures

b.) at-risk for metabolic decompensation and global cerebral edema

c.) who is comatose (GCS 8 or less)?

6 7 8	5 nt, but no	4 Importa	_	_	3 nce	2 importa	limited	7 importan	of LEAS
agement decisions for making clinical	cal manage	ing clinic	for mak	isions	nent dec	anagem	linical n	making c	for r
	9	8	7	6	5	4	3	2	1
	0	0	0	0	0	0	0	0	0

How important is multimodality neuromonitoring in a patient presenting with: a.) cytokine release syndrome-related encephalopathy (e.g. COVID-related, CAR T-cell neurotoxicity syndrome) or other inflammatory condition b.) clinical or radiographic concern for cerebral edema c.) who is comatose (GCS 8 or less)

of LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST important
for	0 making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clinie	int, but <i>no</i> cal manag	t critical ement decisions	for making o	Cri clinical n	itical nanage	ment decisions
1	2 3 4 5 6					7	8	9					
~	0	0	0	0	0	0	0	0					

49

How important is multimodality neuromonitoring in a patient presenting with:

a.) fulminant hepatic failure

Round 1: Median [IOR] 7 [5-8]

b.) clinical or radiographic concern for cerebral edema

c.) who is comatose (West Haven Stage 4)

Round 1: Median [IQR] 7 [5.25-8.75]



How important is multimodality neuromonitoring in a patient presenting with:

a.) cardiopulmonary failure

b.) requiring veno-arterial extracorporeal membrane oxygenation (VA-ECMO)

Round 1: Median [IQR] 6 [3-7]

for	0 maiking	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 Ince nent dec	isions	for mak	4 Importating clini	5 snt, but i cal man	6 not critical agement decisions	for mak	7	8 Crit nical m	9 tical nanage	of MOST importance
1	2 〇	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						

51

New Question

How important is multimodality neuromonitoring in a patient presenting with:

a.) severe acute respiratory failure (e.g. acute respiratory distress syndrome [ARDS])

b.) requiring venovenous extracorporeal membrane oxygenation (VV-ECMO)

d LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST important
for	O making (f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but <i>not</i> i cal manager	critical nent decisions	for making o	Cri linical m	ticol Ianage	ment decisions
1	2	3	4	5	6	7	8	9					
7	0	0	0	0	0	0	0	0					

How important is multimodality neuromonitoring in a patient presenting with:

a.) sepsis

b.) who is comatose (GCS 8 or less) due to underlying septic encephalopathy or shock

Round 1: Median [IQR] 5.5 [3-7]

of LEA	\$7 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importa
for	0 making	f <i>limited</i> clinical n	/ importa nanagen	nce nent dec	isions	for mak	Importa ting clini	int, but not critical cal management dec	Critical isions for making clinical management decision
1	2	3	4	5	6	7	8	9	
C	0	0	0	0	0	0	0	0	



Contexts of Use: BRAIN TISSUE HYPOXIA

Select EACH of the physiologic measurements that you feel are useful to detect and
optimally manage BRAIN TISSUE HYPOXIA of any cause:

Intracranial	Pressure	(ICP)
 intraciania	Liezznie	(ICP)

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)



Contexts of Use: CEREBRAL ISCHEMIA

Select EACH of the physiologic measurements that you feel are useful to detect and
optimally manage CEREBRAL ISCHEMIA of any cause (including subarachnoid
hemorrhage-related delayed cerebral ischemia):

Intracranial	Droccuro	(ICD)
 intracramai	Pressure	(ICP)

Cardiac Output (including associated measures of intravascular volume)

- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- 11/1/2022

Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: AUTOREGULATORY DYSFUNCTION



Select EACH of the physiologic measurements that you feel are useful to detect and	
optimally manage AUTOREGULATORY DYSFUNCTION:	

	Intracranial	Proceuro	(ICP)
_	intracrania	Pressure	(ICP)

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: ACUTE COMA OR DISORDERS OF CONSCIOUSNESS

New	Question
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Select EACH of the physiologic measurements that you feel are useful to detect and optimally manage ACUTE COMA OR DISORDERS OF CONSCIOUSNESS:

Intercontrol Deserves ///	and interaction.	
	°D\	i.
Intracranial Pressure (IN	_r,	1

Cardiac Output (including associated measures of intravascular volume)

- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- 11/1/2022

Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: POST-CARDIAC ARREST ANOXIC BRAIN INJURY

New (Question
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Select EACH of the physiologic measurements that you feel are useful to detect and optimally manage POST-CARDIAC ARREST ANOXIC BRAIN INJURY:

1	Intracranial	Pressure	(ICP)

Cardiac Output (including associated measures of intravascular volume)

- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry
- 11/1/2022

Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: METABOLIC CRISIS OR MITOCHONDRIAL DYSFUNCTION



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Select EACH of the physiologic measurements that you feel are useful to detect and
optimally manage METABOLIC CRISIS OR MITOCHONDRIAL DYSFUNCTION:

Intracranial	Pressure	(ICP)
 interaction and	Liessnie.	(ICF)

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: SEIZURES OR ICTAL-INTERICTAL CONTINUUM PATTERNS



50		
22		

Select EACH of the physiologic measurements that you feel are useful to detect and
optimally manage SEIZURES OR ICTAL-INTERICTAL CONTINUUM PATTERNS:

	Intracranial	Pressure	(ICP)
_	the second contract	1.1.0.0.0.01.0	free 1

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)



Contexts of Use: SPREADING DEPOLARIZATIONS
Select EACH of the physiologic measurements that you feel are useful to detect and	
optimally manage SPREADING DEPOLARIZATIONS:	

	Intracranial	Pressure	(ICP)
~	HILF DET DI HER	1.1.0.0.0.01.0	free 1

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Contexts of Use: INTRACRANIAL HYPERTENSION OR HERNIATION



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Select EACH of the physiologic measurements that you feel are useful to detect and
optimally manage INTRACRANIAL HYPERTENSION OR HERNIATION:

	Intracranial	Pressure	(ICP)
_	inter orea on more	11000000	free 1

- Cardiac Output (including associated measures of intravascular volume)
- Cerebral Perfusion Pressure (CPP)
- Optimal Cerebral Perfusion Pressure (CPPopt)
- Cerebral Autoregulation (e.g. PRx, Mx, ORx)
- End-Tidal Capnography (ETCO2)
- Brain Tissue Oxygen (PbtO2 or PtiO2)
- Jugular Venous Oxygen (SjvO2)
- Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRS) or other optical imaging technology
- Regional Cerebral Blood Flow (rCBF)
- Brain Temperature
- Brain Water Constant (K)
- Cerebral Microdialysis
- Continuous Scalp EEG
- Electrocorticography: Single-wire or Depth Electrode
- Electrocorticography: Strip Electrode
- Full-band (DC or near-DC) EEG Recordings
- Quantitative EEG
- Processed EEG Indices of Anesthesia/Sedation Depth
- Quantitative Pupillometry

11/1/2022 Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography (TCD)

Autonomic Function	(e.g. heart	rate	variability)
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Arterial Blood Pressure (ABP)

Cardiac Telemetry (ECG)

Plethysmography (SpO2)

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Minimum Necessary Technology: Devices & Measurements

How important are each of the following physiologic measurements and devices to your clinical decision-making?

For each question, consider a hypothetical patient who requires the MOST comprehensive multimodality neuromonitoring. Assume that you have access to any and all modalities listed below.

Your experience with specific devices/modalities may inform your decision. If you have *not* had access to a device in your practice but feel it might be useful, please rate as such based on your existing expertise. Please do not consider specific brands or types of devices, rather focus on the measurement parameter itself.

If a measurement modality is important only in conjunction with another measurement, BOTH should be rated as important. For example, if you feel cerebral autoregulation is extremely important and you measure it using rSO2, then rate both as extremely important even if you do not use rSO2 for anything else.

62

Intracranial Pressure (ICP)

Round 1: Median [IQR] 9 [8.25-9]

I LEAS	T importa	ice 1	2	3		_	4	5 6	7 8	9 of MOST importan
for	Of making o	<i>limited</i> linical n	importa nanagen	ince hent dec	isions	for mak	Importa ding clini	ant, but not critical ical management decisions	Cr for making clinical n	itical nanagement decisions
1	2	3	4	5	6	7	8	9		
5	0	0	0	\cap	0	0	0	\bigcirc		

Cardiac Output (including associated measures of intravascular volume)

Round 1: Median [IQR] 6.5 [5.25-7]

of LEAC	0 importa O malking o	f <i>limited</i>	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 ant, but n cal manaj	6 ot critical gement decision	s for ma	7 8 9 of MOST impo				
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()							
6 Ce	4 erebra	al Per	fusior	n Pres	sure	(CPP)									

Round 1: Median [IQR] 8 [8-9]

of LEAS	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but / cal mana	not critical Igement decisions	for making c	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Optimal Cerebral Perfusion Pressure (CPPopt)

Round 1: Median [IQR] 6 [5-7]

for	0 making o	f limited	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Cri linical m	9 tical tanager	of MOST importance
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8 ()	9 ()				

66

Cerebrovascular Autoregulation (e.g. PRx, Mx, ORx)

Round 1: Median [IQR] 7 [5.25-7.75]

of LEA	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but / cal man	not critical agement decisions	for making c	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

End-Tidal Capnography (ETCO2)

Round 1: Median [IQR] 8 [7-9]

of LEA	ST importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	0 making	f limited clinical n	importa	ince nent dec	isions	for mak	Importa ting clini	ant, but not critical cal management decisions	for making c	Cri tinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

68

Brain Tissue Oxygen (PbtO2 or PtiO2)

Round 1: Median [IQR] 7 [6-8]

ofLEA	57 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but / cal man	not critical agement decis	sions	for making c	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

Jugular Venous Oxygen (SjvO2)

Round 1: Median [IQR] 4 [3-6]

of LEA	S7 importa O malking o	f limited	2 /importa nanagen	3 Ince nent dec	isions	for mak	4 Importating clini	5 6 ant, but not critical cal management decisions	7 for making c	8 Cr Ilinical n	9 Itical nanage	of MOST importance ment decisions
1	2 ()	3 ()	4	5 ()	6	7 ()	8	9 ()				

70

Regional Oxygen Saturation (rSO2) using Near-Infrared Spectroscopy (NIRES) or other optical imaging technology

Round 1: Median [IQR] 4.5 [3-6]

of LEA	S7 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but / cal mana	ot critical igement dec	cisions	for making	Cri clinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	Ô	Ô	0	Ó	Ó						

Regional Cerebral Blood Flow (rCBF)

Round 1: Median [IQR] 5 [5-6.75]

for	0 making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but / cal mana	ot critical gement decision	s for i	making c	Cri linical m	tical Ianager	ment decision
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						

72

Brain Temperature

Round 1: Median [IQR] 6 [5-7]

ofLEA	S7 importa	nce 1	2	3			4	5		6			7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but / cal man	not o agen	ritical sent dec	isions	for ma	aking c	Cri linical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9								
0	0	0	0	0	0	0	0	0								

Brain Water Constant (K)

Round 1: Median [IQR] 4 [2-5]

of LEA	S7 importa O malking	nce 1 f <i>limited</i> clinical n	2 importa nanagen	3 ince hent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 for making c	8 Cri linical m	9 of MOST importance tical nanagement decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

74

Cerebral Microdialysis: Lactate & Pyruvate

Round 1: Median [IQR] 6 [5-7]

of LEA	57 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but cal man	not critical agement decisions	for making c	Cri linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Cerebral Microdialysis: Brain Tissue Glucose

Round 1: Median [IQR] 6 [5-7]

for	O making	f <i>limited</i> clinical n	importa nanagen	ince ient dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	for making c	Cri linical m	ticol Ianage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

76

Cerebral Microdialysis: Glutamate

Round 1: Median [IQR] 5 [2.25-6]

ofLEA	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but cal man	not critical agement decisions	for making o	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Cerebral Microdialysis: Glycerol

Round 1: Median [IQR] 4.5 [2-6]

of LEA	S7 importa O making (nce 1 f limited clinical n	2 importa nanagen	3 Ince hent dec	isions	for mak	4 Importating clinit	5 ant, but / cal mana	6 not critical agement decisio	ons	7 for making c	8 Cr dinical n	9 itical nanage	of MOST importance ment decisions
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()						
7	78													

Continuous Scalp EEG

Round 1: Median [IQR] 8 [7-9]

of LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importanagen	ince nent dec	isions	for mak	Importa ting clini	ant, but / cal mana	not critical agement decisions	for making o	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Electrocorticography: Single-wire or Depth Electrode

Round 1: Median [IQR] 5 [3-6]

for	0 making	f limited clinical n	importa	ince hent dec	isions	for mak	Importa ing clini	ant, but not critical cal management decisions	for making cl	Cri inical m	tical lanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

80

Electrocorticography: Strip Electrode

Round 1: Median [IQR] 5 [3-6]

ofLEA	57 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importa ing clini	ant, but i cal man	not critici agement	al decisions	for making	Cr clinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

Full-band (DC or near-DC) EEG Recordings

Round 1: Median [IQR] 5 [3-6]

for	Omaking	f limited	/importa hanagen	ance nent dec	isions	for mak	4 Importa	ant, but i cal mana	b not critical agement decisions	for making o	Crit linical m	g of Acts responses
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()				

82

Quantitative EEG

Round 1: Median [IQR] 7 [5.25-8]

of LEAS	S7 importa O	nce 1 f limited	2 importa	3 ince			4 Importa	5 ant, but	6 not critical		7	8	9 itical	of MOST importanc
for	making	clinical n	nanagen	nent dec	isions	for mak	ting clini	cal man	agement dec	isions	for making	clinical n	nanage	ment decisions
1	2	3	4	5	6	7	8	9						

Processed EEG Indices of Anesthesia/Sedation Depth

Round 1: Median [IQR] 5 [2.25-6]



Extended-Duration (> 30 min) or Frequent (> 1 daily) Transcranial Doppler Ultrasonography

Round 1: Median [IQR] 4 [3-6]

of LEA	17 importa	nce 1	2	3			4	5	6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but / cal mana	not critical agement decision	s for n	naking c	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

86

Autonomic Function (e.g. heart rate variability)

Round 1: Median [IQR] 3 [3-5]



Arterial Blood Pressure (ABP)

Round 1: Median [IQR] 9 [8.25-9]

of LEAST importance 1 2 3	4 5 6	7 8 9 of MOST important
Of <i>limited</i> importance for making clinical management decisions	Important, but not critical for making clinical management decisions	Critical for making clinical management decisions
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	7 8 9 O O O	
88		
Cardiac Telemetry (ECG) Round 1: Median [IQR] 9 [7	/-9]	
of LEAST importance 1 2 3 Of limited importance for making clinical management decisions	4 5 6 Important, but not critical for making clinical management decisions	7 8 9 of MOST importan Critical for making clinical management decisions
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	7 8 9 O O O	
⁸⁹ <i>New Question</i> Plethysmography (SpO2)		
of LEAST importance 1 2 3 Of limited importance for making clinical management decisions	4 5 6 Important, but not critical for making clinical management decisions	7 8 9 of MOST important Criticol for making clinical management decisions
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	7 8 9	

Continuous Core Body Temperature or Continuous Water Temperature (in patients undergoing targeted temperature management)

Round 1: Median [IQR] 8.5 [7-9]

of LEA	57 importa	nce 1	2	3			4	5 6		7	8	9	of MOST important
for	0 maiking (f <i>limited</i> clinical n	/ importa nanagen	nce nent dec	isions	for mai	Importa ing clini	ant, but <i>not critical</i> cal management dec	isions	for making c	Cr linical r	itical nanage	ment decisions
1	2 3 4 5 6					7	8	9					
0	0	0	0	0	0	0	0	0					

Minimum Necessary Technology: Access

How important are each of the following to the use of neuromonitoring data to make care decisions?

If you have no personal experience accessing neuromonitoring data as described below, answer to the best of your abilities based on your existing expertise.

91

Bedside visualization or display of a *single*, current (live) measurement value, e.g. a single numeric value displayed on a device at that moment in time visible in a patient care area.

Round 1: Median [IQR] 8 [5-9]

for	S7 importa O malking o	nce 1 f limited clinical n	2 / importa nanagen	3 Ince nent dec	isions	for mak	4 Importating clinit	5 ant, but / cal mana	6 not critical agement decision	7 s for making	8 Cr clinical n	9 itical nanage	of MOST importance
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9					

92

Bedside visualization or display of *single* measurement trended over time, e.g. a graph of a time-series displayed on a device visible in a patient care area.

Round 1: Median [IQR] 8 [7-9]

of LEAS	ST importa	nce 1	2	3			4	5 6	7 8 9 of MOST importance
for	O making o	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

Bedside visualization or display of *multiple*, current (live) measurement values together on the same screen, e.g. multiple numeric measurement values from different devices displayed on the same screen and visible in a patient care area.

Round 1: Median [IQR] 8 [6.25-9]



94

Bedside visualization or display of *multiple* measurements trended over time and aligned on the same screen, e.g. a graph of several time-series from different devices displayed on the same screen and visible in a patient care area.

Round 1: Median [IQR] 9 [7-9]

e LEA	\$7 importa	nce 1	2	3	1		4	5 6	7 8	9 of MOST importan
for	O making o	f <i>limited</i> clinical n	importa	nce nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decision	for making clinical n	itical nanagement decisions
F	2 3 4 5 6					7	8	9		
1	-	-		~	÷.		<u> </u>	2		

New Question

Bedside visualization or display of summary or aggregate data such as "Area Under the Curve", "Burden" or "Dose" on a device visible in a patient care area.



96

Access to data with high temporal resolution (1 or more data points every minute) including clinically-standard data such as heart rate, arterial blood pressure in addition to neuromonitoring-specific data.

Round 1: Median [IQR] 7 [7-9]

of LEA	\$7 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importa
for	O making	f limited clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa	int, but not critical cal management decis	Critical isions for making clinical management decision
1	2 3 4 5					7	8	9	
0	0	0	0	0	0	0	0	0	

Access to data at waveform resolution, such as ECG waveforms, arterial blood pressure or intracranial pressure waveforms, or EEG signals.

Round 1: Median [IQR] 7.5 [7-9]

of LEA	17 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	/ importa nanagen	nce nent dec	isions	for mak	Importa ding clini	int, but not critical cal management de	cisions	for making c	Cri linical m	ticol nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

98

Integration with the Electronic Health Record through capture of single measurement values, e.g. within flowsheet rows or tables.

Round 1: Median [IQR] 7 [5.25-9]

of LEA	S7 importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	0 making	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but not cal manage	critical ment decisions	for making c	Cri linical m	tical anage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Integration with the Electronic Health Record through display (in a table or graph) of multiple different measurement values together on a single panel, tab, or screen.

Round 1: Median [IQR] 8 [6-9]



100

Ability to manipulate data visualization or display AT BEDSIDE, e.g. zooming in or out (time scaling), scrolling back and forth in time, or selecting which neuromonitoring measurements to display.

Round 1: Median [IQR] 7 [7-9]

of LEA	17 importa	nce 1	2	3			4	5 6	7 8 9 of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisions	Critical for making clinical management decisions
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

Ability to annotate neuromonitoring data AT BEDSIDE to indicate clinical events or other contextual data.

Round 1: Median [IQR] 8 [7-9]

of LEAS	S7 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but <i>not critical</i> cal management decisions	for making c	Cri linical m	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

102

Ability to display neuromonitoring data AT BEDSIDE linked with annotations to indicate clinical events or other contextual data.

Round 1: Median [IQR] 8 [6.25-9]



Ability to display neuromonitoring data AT BEDSIDE linked with Electronic Health Record information, e.g. laboratory values or medication administration information.

Round 1: Median [IQR] 7 [6-8]

of LEA	\$7 importa	nce 1	2	3			4	5 6	5	7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	nt, but not cri cal manageme	itical ent decisions	for making c	Cri linical n	tical nanage	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

104

New Question

Ability to display therapeutic decision-making aids, decision support tools or diagnostic/management algorithms for clinical staff AT BEDSIDE, e.g. interactive prompts or step-wise clinical guidance.

of LEA	57 importa	nce 1	2	3			4	5	5	7	8	9	of MOST importance
for	O making	f limited clinical n	/ importa nanagen	nce nent dec	isions	for mak	Importation in the second seco	ent, but <i>not cr</i> cal managem	ritical ent decisions	for making c	Cri linical m	tical ianage	ment decisions
1	2	3	4	5	6	7	8	9					
Ò	Õ	Ó	Ó	Õ	Ô	Ó	Õ	Ô					

Ability to visualize or display neuromonitoring data in real-time REMOTELY (from a separate reading room or from home).

Round 1: Median [IQR] 8 [7-9]

of LEA	S7 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	nt, but not critical cal management decision	for making o	Cri dinical n	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

106

Ability to manipulate and review displayed neuromonitoring data in real-time REMOTELY (from a separate reading room or from home), e.g. choosing specific neuromonitoring measurements to display or zooming in or out of the data.

Round 1: Median [IQR] 8 [7-9]

of LEA	S7 importa	nce 1	2	3			4	5 6		7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa	ince nent dec	isions	for mak	Importa	ant, but <i>not critic</i> cal management	al decisions	for making c	Crit linical m	tical anager	ment decisions
1	2	3	4	5	6	7	8	9					
ò	Õ	Õ	Ó	Õ	Õ	Ò	Õ	Ó					

Ability to annotate neuromonitoring data REMOTELY to indicate clinical events or other contextual data.

Round 1: Median [IQR] 7 [5.25-9]

of LEA	S7 importa O making (f <i>limited</i>	2 importanagen	3 Ince hent dec	isions	for mak	4 Importating clini	5 6 int, but not critical cal management decisions	7 for making c	8 Cri finical m	9 of MOST in tical nanagement decis	ions
1	2 ()	3 ()	4	5 ()	6	7 ()	8	9				

108

Ability to display neuromonitoring data REMOTELY linked with bedside annotations that indicate clinical events or other contextual data.

Round 1: Median [IQR] 7 [6-9]

of LEA	S7 importa	nce 1	2	3			4	5	6	_	7	8	9	of MOST importance
for	making	clinical n	nanagen	nce nent dec	isions	for mak	importa ing clini	cal manaj	ement decisi	ions	for making	clinical n	hanage	ment decisions
1	2	3	4	5	6	7	8	9						
0	0	0	0	0	0	0	0	0						

Ability to display neuromonitoring data REMOTELY linked with Electronic Health Record information, e.g. laboratory values or medication administration information.

Round 1: Median [IQR] 7 [6-9]

of LEA	S7 importa	nce 1	2	3			4	5 6	7	8	9	of MOST importance
for	O making (f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	int, but not critical cal management decisio	ns for making	Cr clinical r	itical nanage	ment decisions
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

110

Ability to access neuromonitoring data for use in other software packages (e.g. Excel or R) by downloading from a hardware interface (e.g. bedside download of data through a USB drive).

Round 1: Median [IQR] 5.5 [3-8]

of LEA	\$7 importa	nce 1	2	3	J		4	5 6		7	8	9	of MOST importance
for	O making o	f <i>limited</i> clinical n	importa nanagen	nce nent dec	isions	for mak	Importation in the second seco	ant, but not critical cal management dec	isions	for making cli	Crit nical m	icol anagei	ment decisions
1	2	3	4	5	6	7	8	9					
0	0	0	0	Ô	Ô	Ó	Ó	Ó					

Ability to access neuromonitoring data for use in other software packages (e.g. Excel or R) through software or server-based interface, e.g. data is accessible from a server.

Round 1: Median [IQR] 7 [3-8]



112

New Question

Ability to access neuromonitoring data in REAL-TIME for use in data analytic tools (e.g. ICM+ or Persyst) either through a network interface or hardware connection.

of LEA	17 importa	nce 1	2	3			4	5 6	7 8	9 of MOST importance
for	O making	f <i>limited</i> clinical n	/ importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ent, but not critical cal management decisions	Cri for making clinical n	itical nanagement decisions
1	2	3	4	5	6	7	8	9		
0	0	0	0	0	0	0	0	0		

New Question

Ability to access neuromonitoring data in REAL-TIME for use in a secure cloud-based platform capable of deploying data analytic tools (e.g. machine learning algorithms).



114

Ability to set alarms or thresholds to alert staff AT BEDSIDE, e.g. via flashing colors or alarm sounds.

Round 1: Median [IQR] 7 [6-8.75]

N.B. alarms or thresholds may be based on single or multiple parameters

of LEA	ST importa	nce 1	2	3			4	5	6	7	8	9	of MOST importance
for	O making	f <i>limited</i> clinical n	importa nanagen	ince nent dec	isions	for mak	Importa ing clini	ant, but no cal manag	ement decisions	for making c	Crit linical m	ticol lanage	ment decisions
			- 200			6	2001					- 19	
1	2	3	4	5	6	7	8	9					
0	0	0	0	0	0	0	0	0					

Ability to set alarms or thresholds to alert staff REMOTELY, e.g. through push notifications or email.

Round 1: Median [IQR] 6 [4.25-8]

N.B. alarms or thresholds may be based on single or multiple parameters

of LEAST importance 1 2 3 Of <i>limited</i> importance for making clinical management decisions						for mak	4 Importa ing clini	5 6 Int, but not critical cal management decision	7 for making	8 Cri clinical n	9 of MOST importance itical nanagement decisions
1 ()	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()			

Minimum Necessary Work: Agree or Disagree

For the following questions, indicate the level of agreement about the following statements.

116

I feel that most intensivists staffing an ICU and caring for patients with brain injuries are able to adequately INTEGRATE AND INTERPRET multimodality neuromonitoring data as part of daily clinical care in order to make management decisions.

Round 1: Median [IQR] 3 [2-4]

strong)	y DISAGRE	1	2	3			4	5 6		7	8 9	strongly AGREE
		Disa	ngree			N	either /	gree nor Disagre	e		Agree	
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

117

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have adequate TIME to fully review all available multimodality neuromonitoring data as part of daily clinical care.

Round 1: Median [IQR] 3 [2-3]



I feel that most intensivists staffing an ICU and caring for patients with brain injuries have all the necessary TECHNOLOGY to integrate and interpret multimodality neuromonitoring data as part of daily clinical care.

Round 1: Median [IQR] 2 [1-3]



119

I feel that most intensivists staffing an ICU and caring for patients with brain injuries <u>have TECHNICAL KNOWLEDGE</u> sufficient to troubleshoot device errors and to identify artifactual or erroneous multimodality neuromonitoring data.

Round 1: Median [IQR] 2 [1-3]

		Disa	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

I feel that most intensivists staffing an ICU and caring for patients with brain injuries have CLINCAL KNOWLEDGE of brain physiology sufficient to use multimodality neuromonitoring data in making clinical decisions as part of daily clinical care.

Round 1: Median [IQR] 5 [3-6]



121

I feel most intensivists staffing an ICU and caring for patients with brain injuries would find regularly written reports summarizing multimodality neuromonitoring data and providing clinical interpretation/correlation to be helpful in making clinical decisions as part of daily clinical care.

Round 1: Median [IQR] 7.5 [7-9]

strong	y DISAGRE	1	2	3	1		4	5 6	7 8 9 strongly AGREE
		Disa	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	
I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires access to raw data for data manipulation outside of the devices on which data is measured, e.g. for pre-processing/cleaning, aggregation, integration with other data, computational analytics, and/or statistical analysis.

strong	y DISAGRE	1	2	3			4	5	6	7	8	9 strongly AGREE
	Disagree						either /	Agree no	or Disagree		Agree	
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

Round 1: Median [IQR] 8 [7-9]

123

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring data requires review of a variety of time-scales - from hours to days of data - in order to make clinically-meaningful inferences from the information.

Round 1: Median [IQR] 8.5 [8-9]

strong	y DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGRE
	Disagree						either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

122

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring data is part of neurocritical care and <u>is NOT distinct</u> from the work of either critical care or general clinical duties as it exists currently.

strong	y DISAGRE	Disa	2 agree	3		N	4 either A	5 6 Agree nor Disagree	7 8 9 strongly AGAEE Agree
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8	9 ()	

125

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring data is part of neurocritical care and <u>would NOT be distinct</u> from the work of either critical care or general clinical duties *if* a simplified user interface is provided for bedside users without expertise and/or experience.

strong	y DISAGAR	1	2	3	1		4	5 6	7 8 9 strongly AGREE
		Dis	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires specific skill or expertise to synthesize multiple data trends over time that reflect disease trajectory.

strong	y DISAGAE	t 1 Disa	2 agree	3		N	4 either A	5 gree nor D	5 sagree	7 8 9 stro Agree	ngiy AGREE
1	2 ()	3 ()	4	5 ()	6 ()	7 ()	8 ()	9 ()			

127

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires skill or expertise that is NOT routinely developed by any single fellowship training programs that exist currently.

strong	y DISAGRE	1	2	3			4	5 6	7 8 9 strongly AGAEE
		Dis	agree			N	either /	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires integration with both brain-specific data *and* systemic data traditionally measured during critical care (e.g. hemodynamic information).

strong	y DISAGRE	1	2	3			4	5	6	7	8	9	strongly AGREE
		Disa	agree			N	either A	gree no	r Disagree		Agre	e	
1 ()	2 ()	3 ()	4 ()	5 ()	6 ()	7 ()	8	9 ()					

129

New Question

I feel that the INTEGRATION AND INTERPRETATION of multimodality neuromonitoring requires clinical context and that 'clinical correlation' is a central component of this process.



New Question

I feel that the APPLICATION AND MAINTENANCE OF EQUIPMENT AND TECHNOLOGIES related to multimodality neuromonitoring is time intensive for a clinician INDEPENDENT of other clinical duties.

strong	y DISAGRE	e 1 Disa	2 agree	3		N	4 either A	5 Agree nor	6 Disagree	7 8 9 str Agree	ongly AGREE
1	2 ()	з ()	4	5 ()	6 ()	7 ()	8	9 ()			

131

New Question

I feel that the SYNTHESIS AND INTERPRETATION of multiple neuromonitoring data trends is time intensive for a clinician INDEPENDENT of other clinical duties.



New Question

I feel that existing billing codes for critical care (e.g. CPT 99291 or 99292) adequately capture the WORK of multimodality neuromonitoring.

N.B. if your practice exists in an area in which billing codes are not used to capture effort associated with clinical care, please leave this question blank



133

New Question

I feel that existing billing codes for other neurophysiologic procedures such as continuous video EEG monitoring (e.g. CPT 95720) or intraoperative monitoring (e.g. CPT 95941) adequately capture the WORK of multimodality neuromonitoring.

N.B. if your practice exists in an area in which billing codes are not used to capture effort associated with clinical care, please leave this question blank



New Section Operationalizing Multimodality Neuromonitoring: Agree or Disagree

Assume you are wanting to start or expand the use of comprehensive multimodality neuromonitoring at your institution. What elements would be helpful in order to move forward in operationalizing or implementing monitoring for patients with acute brain injuries?

For the following questions, indicate the level of agreement about the following statements.

134

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could provide for bedside users (e.g. clinical care team) an interface that facilitates an understanding of multiple parameters in the context of a specific disease process.

strong	y DISAGAE	Disa	2 agree	3		N	4 either /	5 Agree nor	6 Disagree	7	8 9 Agree	strong	ly AGREE
1 ()	2 ()	3 ()	4 ()	5 ()	6	7 ()	8 ()	9 ()					

135

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could provide for bedside users (e.g. clinical care team) an interface that displays trend data on a single screen that can be used to manipulate and explore data.

strong	y DISAGRE	1	2	3	1		4	5 6	7 8 9 strongly AG
	Disagree						either A	Agree nor Disagree	Agree
1	2	3	4	5	6	7	8	9	

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I had could enhance clinical confidence in our monitoring data by using software tools to identify or remove artifacts within real-time monitoring data that limits clinical interpretation by bedside users (e.g. clinical care team).

strong	y DISAGRE	1	2	3			4	5 6		7 8 9 strongly A	GMEE
		Disa	agree			N	either /	Agree nor Disa	gree	Agree	
1 ()	2 ()	3 ()	4	5	6	7 ()	8	9			

137

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I had could enhance clinical confidence in our monitoring data by providing transparency for the methods used to derive calculations or summary statistics.

strong	y DISAGRE	1 Disa	2 agree	3	1	N	4 either /	5 6 Agree nor Disagree	7 8 9 strongly ACAEE Agree
1	2 ()	3 ()	4	5 ()	6	7 ()	8	9	

138

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could provide remote access to monitoring data for members of the clinical care team.

strong	strongly DISAGREE 1 2 3						4	5 6]	7 8 9 strongly AGAE		
	Disagree						either A	Agree nor Dis	agree	Agree		
1	2	3	4	5	6	7	8	9				
0	0	0	0	0	0	0	0	0				

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could identify necessary Information Technology (IT) or Clinical Engineering personnel to overcome technological hurdles that limit access to monitoring data at my institution.

strong	y DISAGRE	1	2	3			4	5 6		7 8 9 strongly AGAs		
	Disagree					N	either A	Agree nor Disa	gree	Agree		
1 ()	2 ()	3 ()	4	5 ()	6	7 ()	8	9 ()				

140

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I invested in education for bedside users (e.g. clinical care team) focused on understanding the parameters being measured and why.



141

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I invested in education for bedside users (e.g. clinical care team) focused on learning how to RESPONSD to monitoring data.



139

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I disseminated existing evidence-based data and consensus-based care protocols to bedside users (e.g. clinical care team).



143

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I were to standardize WHO is monitored and by WHICH technologies.



144

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I were to develop clinical management algorithms based on patterns within monitoring data that can be identified by bedside users (e.g. clinical care team)



I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could identify physiologic thresholds and other findings during monitoring that would mandate clinical action or trigger clinical judgement.



146

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I had access to a standardized lexicon of patterns that occur in and between physiologic variables associated with specific underlying biology or clinical relevance.



I feel I can best operationalize multimodality neuromonitoring in my clinical practice <u>now</u> if I could enlist staff and/or trainees to provide expertise in the technical and clinical aspects of our monitoring devices at all times (including nights or weekends).



148

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I could hire or enlist technologists, advanced practice providers and/or nursing educators to be available to provide expertise in the technical and clinical aspects of our monitoring devices at all times (including nights or weekends).



I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if my institution could provide adequate time and support for a dedicated staff member to perform clinical interpretation of real-time monitoring data (e.g. a neuromonitoring 'reader').



150

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if a daily communication of information obtained from monitoring was made available either through notes in the Electronic Health Record or by sending emails to the clinical care team (e.g. neuromonitoring 'reports').



I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if my institution had a staff member that acted as a 'clinical champion' to encourage the use of monitoring.



152

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if there was a CENTRALIZED expert reader through remote tele-health review of patients undergoing monitoring at my institution.



153

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I were to directly engage the multiple stakeholders that are involved in the day-to-day care for patients undergoing monitoring, including neurocritical care, neurosurgery, neurology and others.



I feel I can best operationalize multimodality neuromonitoring in my clinical practice now if I scheduled regularly-held multidisciplinary case conferences to discuss relevant monitoring cases with others involved in day-to-day care for patients undergoing monitoring.



155

I feel I can best operationalize multimodality neuromonitoring in my clinical practice now by developing a business plan that financially incentivizes my hospital to invest in necessary capital expenditures.



I feel I can best operationalize multimodality neuromonitoring in my clinical practice <u>now</u> if there were a reimbursement strategy (e.g. a dedicated CPT code for neuromonitoring) to support dedicated clinicians to perform interpretation and reporting of monitoring data for use by clinical care teams in caring for patients with brain injuries.

New Section Reporting Elements

For the following items, assume you are the attending physician for a care team caring for a patient with acute brain injuries. *Each day* you receive a report related to multimodality neuromonitoring. Which elements are important to make clinical decisions?

Assume data has been individualized and tailored to any physiologic measurements or modalities that you would find useful.

Select each reporting element you would find important <i>each day</i> as the attending physician responsible for a patient with acute brain injury undergoing multimodality neuromonitoring.
Clinical Encounter Information (disease or injury mechanism, disease severity)
Time since injury or onset of disease process
Daily clinical information including clinical exam (GCS/NIHSS), medications of interest, continuous infusions and their ranges or trends, and relevant clinical events
Data validity (e.g. artifacts, malfunction of specific modalities)
Measurement values for each modality including summary statistics, # of "events" (such as ICP elevations or periods of brain hypoxia), "dose" (AUC) of insults
Trends over time for each modality
Inter-relationships between brain-specific measurements and hemodynamics
Inter-relationships between brain-specific measurements and pulmonary function
Inter-relationships between physiologic measurements and their changes in response to <u>specific clinical</u> events (e.g. treatment, medication administration, deterioration of neurologic examination)
Identification of an optimum CPP and summary of autoregulatory information
Synthesis of monitoring information: binary (e.g. present or absent) summary of specific "events" (e.g. 'seizures were present' or 'brain tissue hypoxia was not observed')
Synthesis of monitoring information: phenomenologic interpretation or description of patterns that suggest particular pathology (e.g. 'the intracranial pressure correlated with arterial blood pressure suggesting dysfunction in autoregulation' or 'rising LPR and lower PbtO2 was seen suggesting developing ischemia')
Synthesis of monitoring information: diagnostic interpretation (e.g. 'ischemia was flow-dependent and occurred during periods of hypotension' or 'brain tissue hypoxia was related to increased metabolic demand in the setting of frequent seizures')
Identification of hypotheses for clinical care team to explore (e.g. 'brain tissue hypoxia may have

responded to increases in peripheral oxygenation') and suggestions for goals of care (e.g. 'consider optimizing SpO2 to evaluate for a response in brain tissue oxygen')

Description of significant CHANGES since prior reporting (e.g. 'Since the day prior, there is increasing brain tissue hypoxia')

Predictions or probability assessments for adverse events (e.g. ICP crises or brain tissue hypoxia) to occur over the next 24-hr period

Training Standards: Agree or Disagree

For the following questions, indicate the level of agreement about the following statements.

158

I feel that specific training or expertise is required to adequately prepare clinicians to understand and interpret multimodality neuromonitoring information.

Round 1: Median [IQR] 8 [7-9]



159

I feel that clinical training programs in the <u>neurological specialties</u> (e.g. neurocritical care or neurophysiology) provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.

Round 1: Median [IQR] 5.5 [3.25-7]



I feel that clinical training programs in <u>anesthesia and/or intensive care</u> provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.

Round 1: Median [IQR] 6 [3.25-6.75]



161

New Question

I feel that clinical training programs in <u>neurosurgery</u> provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.

1 2 3 4 5 6 7 8 9 0 0 0 0 0 0 0 0 0

New Question

I feel that clinical training programs in <u>emergency medicine</u> provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information.



163

New Question

I feel that clinical training programs in <u>specialty nursing</u> provide a knowledge base that adequately prepares clinicians to understand and interpret multimodality neuromonitoring information



I feel that ALL clinical training programs for practitioners who will be taking care of brain injured patients should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring.

Round 1: Median [IQR] 8 [7-9]



165

I feel that ONLY clinical training programs at centers that regularly use multimodality neuromonitoring should provide education dedicated specifically to understanding the technical and clinical aspects of multimodality neuromonitoring.

Round 1: Median [IQR] 5 [2.25-7]



New Question

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information DOES NOT require additional training in clinical neurophysiology or EEG regardless of primary specialty training.



167

New Question

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information DOES require additional training in clinical neurophysiology or EEG regardless of primary specialty training.

1 2 3 4 5 6 7 8 9 0 0 0 0 0 0 0 0 0

New Question

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information requires additional training in data management or health informatics.



169

New Question

I feel that an adequate knowledge base to understand and interpret multimodality neuromonitoring information requires additional training in bioengineering, signal analysis, or time-series analysis



New Section Core Training Concepts

Consider you are developing a core training curriculum for multimodality neuromonitoring. Which core concepts are important?

170

Select each core concept you feel is critically important for a clinician to have an adequate knowledge base for understanding and interpreting multimodality neuromonitoring information.

Critical care of patients undergoing monitoring

Cerebral physiology (e.g. cerebral hemodynamics and autoregulatory function, ischemia, tissue hypoxia, intracranial compliance)

Cellular physiology including concepts underlying energy metabolism, cell death, and the neurovascular unit

Mechanics of monitoring devices (e.g. knowledge that a measurement of the partial pressure of oxygen is made by fiberoptic sensor) and pitfalls

Technical aspects of monitoring devices (e.g. hardware connectivity, troubleshooting artifacts related to device malfunction)

Existing evidence for the use and interpretation of multimodality neuromonitoring data

Interactions between brain-specific data AND systemic data traditionally measured during critical care (e.g. hemodynamic information)

Standard EEG analysis and interpretation, including recognition of seizures

Full-band EEG analysis and interpretation, including recognition of both seizures and spreading depolarizations

Methods for measuring autoregulation (e.g. moving average correlation coefficients between different parameters) and pitfalls

Data management or health informatics

Signal analysis and/or time-series analysis techniques

New Section Educational Format: Agree or Disagree

For the following questions, indicate the level of agreement about the following statements.

171

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through SIMULATION or SIM-BASED LEARNING.



172

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through HANDS ON WORKSHOPS OR SEMINARS.



I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through CLINICAL PRACTICE OR BEDSIDE TEACHING.



174

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through CASE-BASED LEARNING.



175

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through ONLINE, SELF-PACED MODULES.



I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through MULTIDISCIPLINARY CASE CONFERENCES.



177

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through DEVELOPMENT OF A CORE CURRICULUM.



178

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through SUPERVISED PERFORMANCE and DEMONSTRATION OF PROCEDURAL COMPETANCY.



I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring is best acquired through DEDICATED FELLOWSHIP TRAINING.



180

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring should be recognized through an online Certification process supported through collaborative partners interested in advancing neuromonitoring.



I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring should be recognized through a Certification process supported through national societies (e.g. Neurocritical Care Society [NCS], American Clinical Neurophysiology Society [ACNS], or the American Society of Neurophysiologic Monitoring [ASNM]).



182

1 2 3 4 5 6 7 8 9 0 0 0 0 0 0 0 0 0

I feel that training and expertise necessary to understand and interpret multimodality neuromonitoring should be recognized through formal Board certification (e.g. through the United Council for Neurological Subspecialties or the American Board of Medical Specialties).

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