Early rehabilitation – step down from the ICU

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5th International Symposium on Post Cardiac Arrest Care 2022

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October 21st, 2022 10.30-10.50

Neurointensive Stepdown Unit & Hammel Neurorehabilitation and Research Centre

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NISU was established in 2008 budding from the *Clinic of Early Neurorehabilitation* at HNRC.

NISU admits patients with central neurological injury with special needs of observation, intensive care and rehabilitation, The unit is staffed by trained neurointensive nurses, physicians and shares physio- and occupational therapists with Hammel.

N1 holds six beds for neurointensive stepdown patients in rehabilitation (**NISU**), and two beds for medical intensive care patients and postoperative patients in prolonged recovery.

HNRC is a highly specialized hospital for neurorehabilitation. Since 2000 responsible for patients in Western part of Denmark with acquired brain damage.

The Centre holds 118 beds: 51 highly specialized,beds, 67 regional beds in Hammel, Skive & Lemvig).
In addition six neurointensive stepdown beds at NISA in Silkeborg.
Physio- and occupational therapists from **Hammel Neurorehabilitation and Research Centre** initiate treatment **NISU** and continue at HNRC.

"Keep the patient alive till the brain wakes up!" ASO

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CNS: prevention of secondary injury – thrombosis, hypoperfusion, hypoxia, PSH. Alternating rest/activity, prevent consequences of dysphagia, central apnoea, dysregulated CV control.
Rest & rest after therapeutic and nursing activities.

Kidney function: balances of fluids & electrolytes, acid/base regulation (a.m. Stewart), CCl.

Ventilatory: tracheostomy, protection of airway against penetration/aspiration, weaning of respiratory support (PS/PEEP), HME, thoughts on pulmonary microbiome.

Increased vigilance towards changes in function of vital organ and parameters.
Low threshold for ECG, UCG, EEG, CTC, MRC, microbiological surveillance.
Frequent consultations with ancillary specialties (psychology, psychiatry, infectious diseases, neurology, radiology, cardiology, &c.)

Cardiovascular: normalisation of rhythm & frequency, regulation of flow & pressure, counter hypo-/hyperactivity. Volume vs tone.

Ethical considerations:
WD/WHLST, frequent consultations with next-of-kin, the retrospective nature of prognostics, hope

Nutrition: **E**nergy **P**roduction **R**ate from Indirect Calorimetry, alt. VCO_2+approximation, Estimating Equations. PEG. Nitrogen balance.

Clinical modus operandi Adherence to clinical guidelines vs the 4 Ms (willing to expand, if you ask)

Dedicated track of care for survivors of heart arrest

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OHCA patients admitted to Aarhus University Hospital, Cardiothoracic ICU:

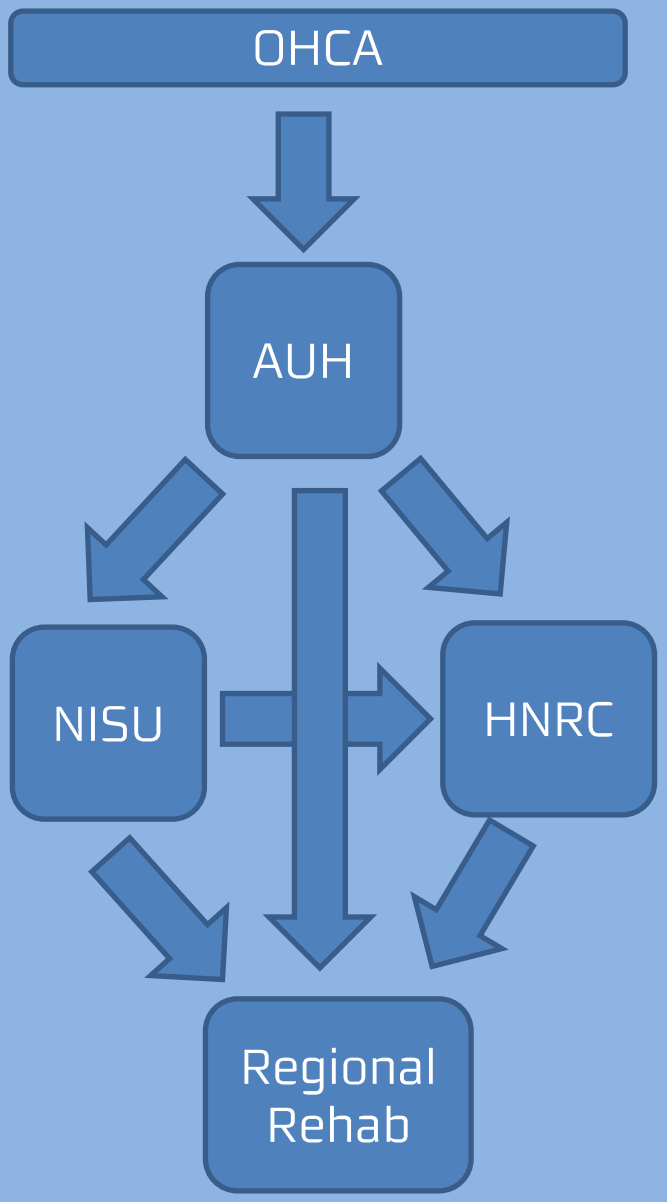
1. Interventional Cardiology lab: CAG, ±stenting
2. IF no incriminating findings on CAG or IF suspicion of neurotrauma: CTC, ± neurosurgical intervention.
3. Transfer to ICU: sedation (remifentanil, propofol), TTM abandoned post TTM1 & 2. Often PDT and PEG performed.

IF no recovery of consciousness after cessation of sedation and IF non status-EEG, IF positive SSEP, and IF CTC shows no ICH, no infarction, **referral to the Neurointensive Stepdown Unit** is considered based on

1) Comorbidity
2) Functional status before OHCA
3) ± bystander CPR, duration no flow, low flow, ROSC
4) CAG results, ±therapy
5) TTE/TEE
6) Neurological status. Prognosis > pessima (bilateral pupillary & corneal reflexes present, SSEP > 24 must be present)
7) State of consciousness: coma (no response to stimuli), vegetative state (opening eyes, no further response), minimal conscious (fluctuating, reproducible responses to stimulation) assessed by Coma Recovery Scale-Revised.

At **NISU** combined neurointensive care and early, highly specialised neurorehabilitation are initiated. Weaning from intensive care to general medical care. Referral to HNRC. Treatment and training continued until saturation of functional scores, EFA and FIM.

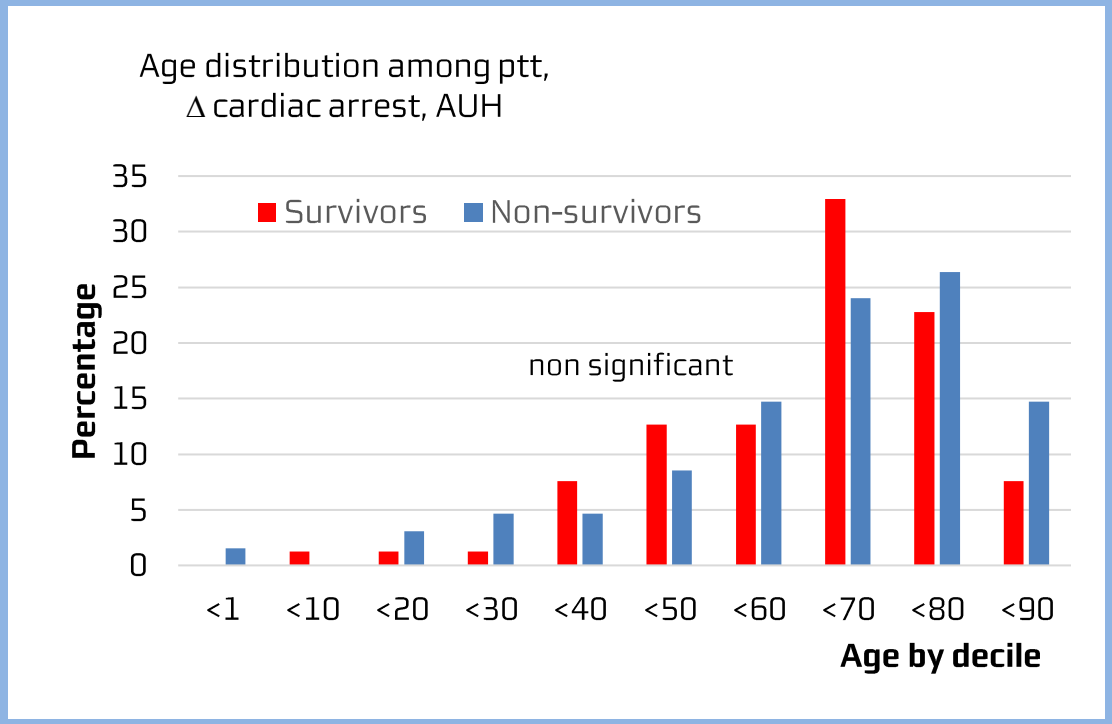
No business as usual.



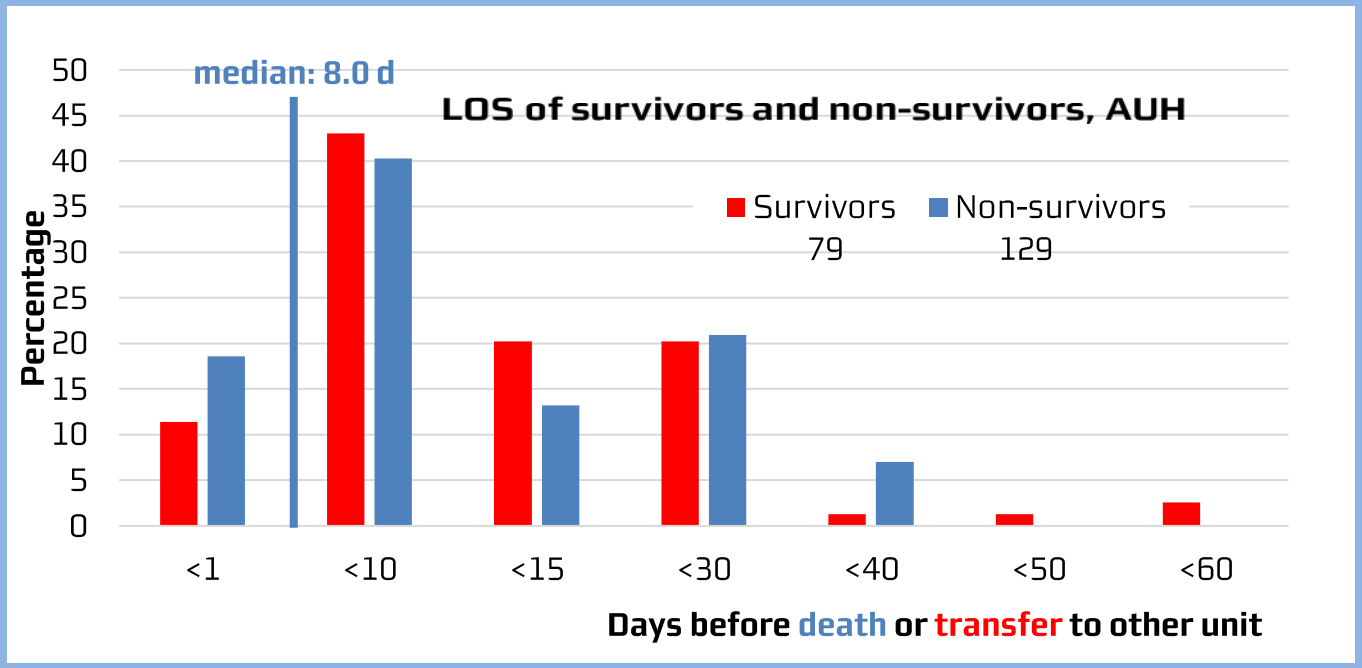
Sept. -18 to Sept. -22, 5 years
Main diagnoses

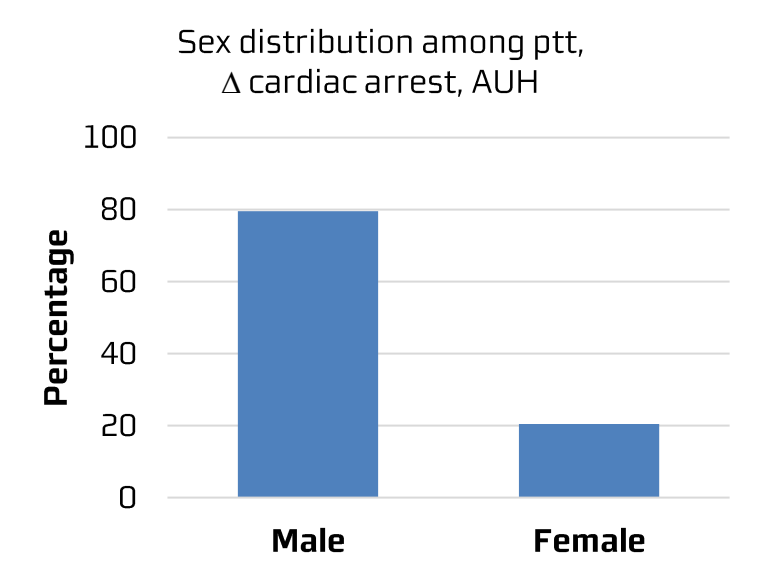
September -18 to September -22		
ICD-10	I46.0 + I46.9 + G93.1	
Hospital	Cardiac arrest with successful resuscitation Cardiac arrest Anoxic brain damage	LOS, median, days
AUH	79	8
NISU	50	18.5
HNRC	8	26

Demographics of patients suffering from CA and/or anoxic brain damage, AUH 2018-22

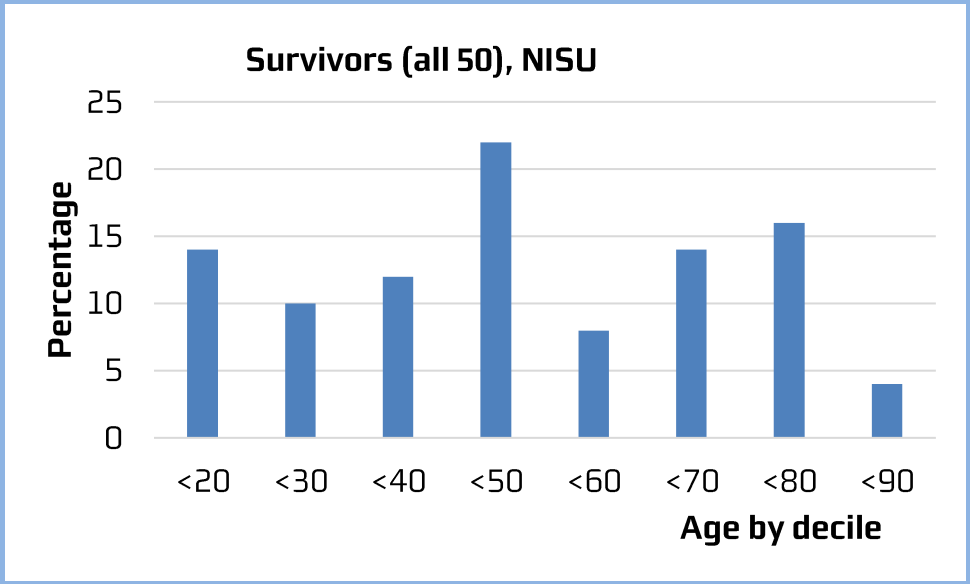


Demographics of patients suffering from CA and/or anoxic brain damage, AUH 2018-22

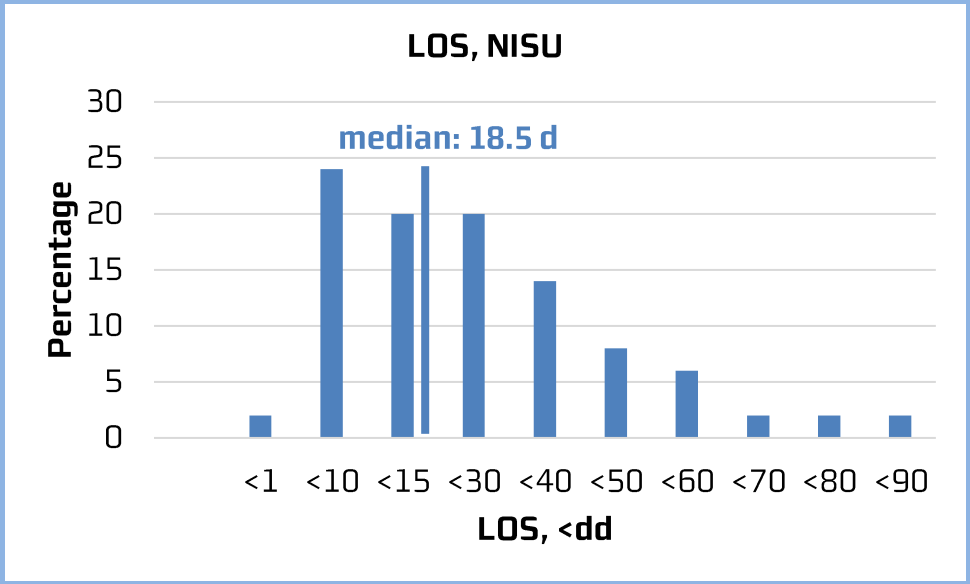


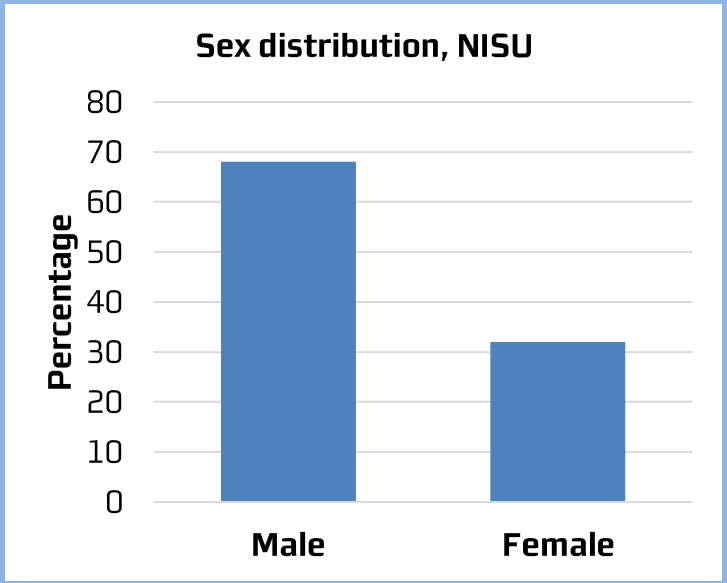


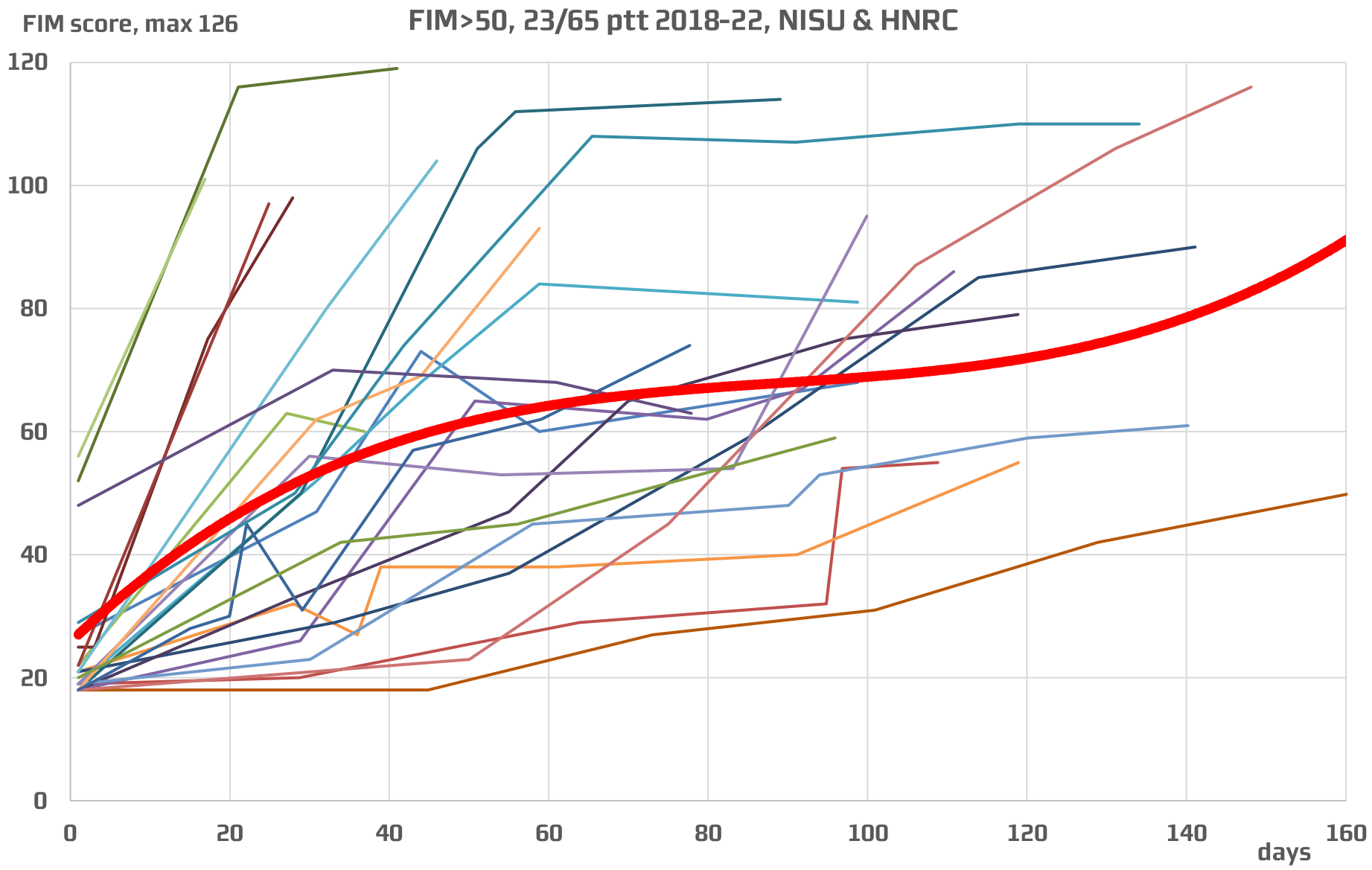
Demographics of patients suffering from CA and/or anoxic brain damage, NISU 2018-22

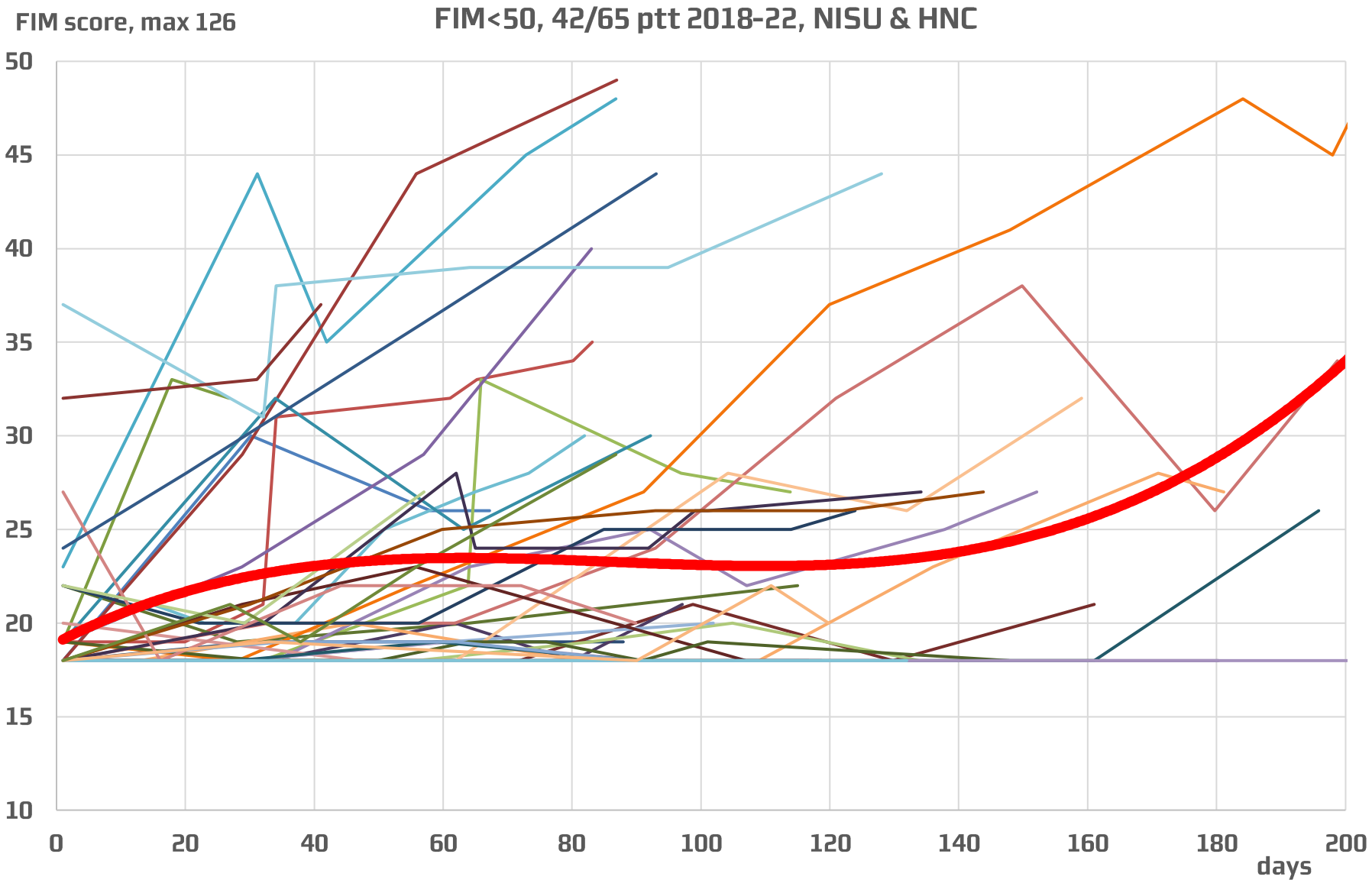


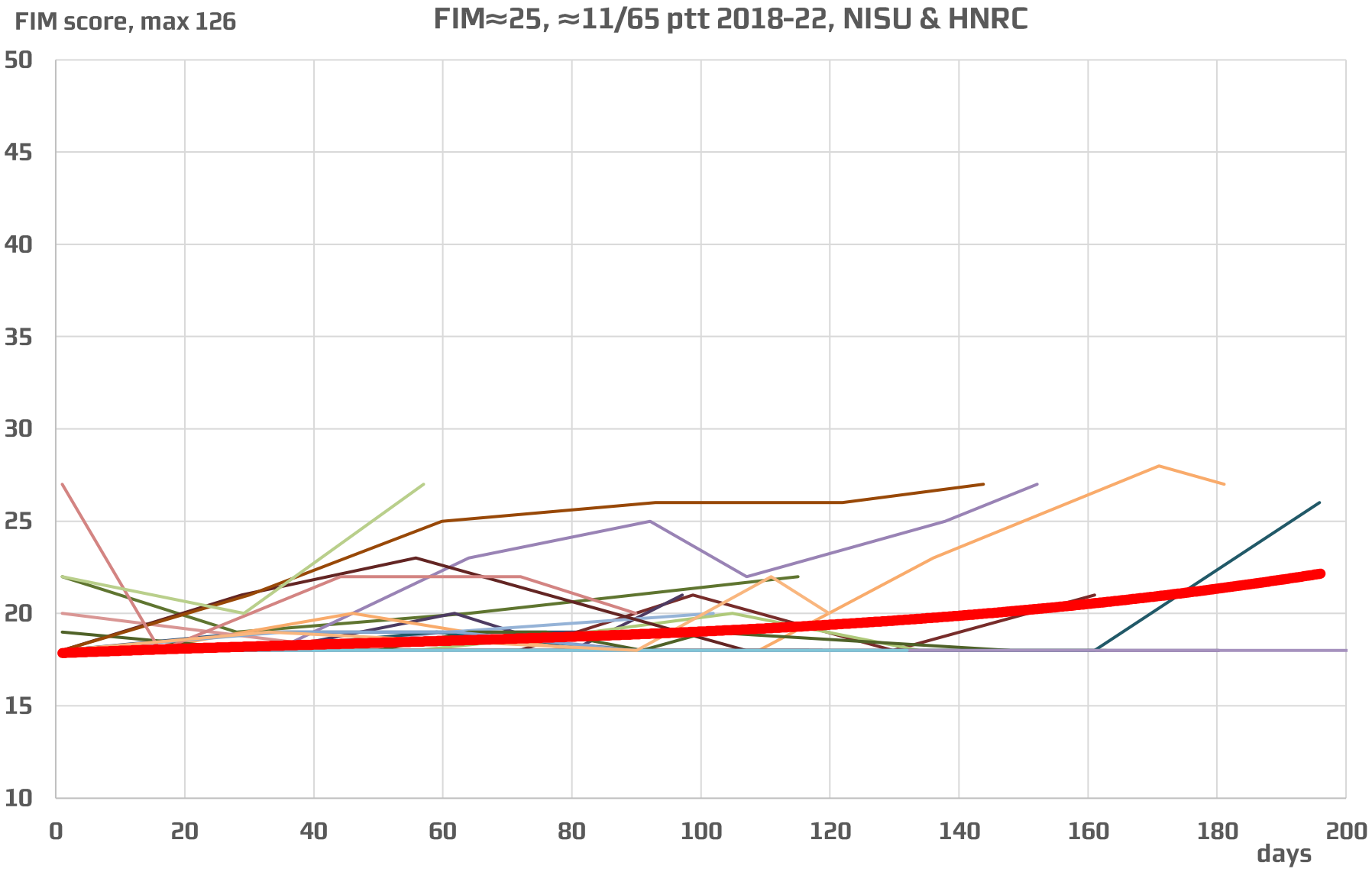
Demographics of patients suffering from CA and/or anoxic brain damage, NISU 2018-22






FIM score, max 126
FIM>50, 23/65 ptt 2018-22, NISU & HNRC
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
days


FIM score, max 126
FIM<50, 42/65 ptt 2018-22, NISU & HNC
50
45
40
35
30
25
20
15
10
0
20
40
60
80
100
120
140
160
180
200
days


FIM score, max 126
FIM≈25, ≈11/65 ptt 2018-22, NISU & HNRC
50
45
40
35
30
25
20
15
10
0
20
40
60
80
100
120
140
160
180
200
days

Interdisciplinary Rehabilitation, 24 y M
AUH – NISU – HNRC - ward facility

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Premorbid psycological & physical status: normal health, enjoys outdoor life, studying economy and psychology, premature return from overseas term. No smoking, no illicit drug use.
Deteriorating mental health, ongoing psychiatric diagnosing, mobile call before suicidal strangulation. PA 10 minutes later. Cut down, CA, CPR, no flow 10 min, low flow 4 min until ROSC.

Interdisciplinary Rehabilitation, 24 y M
AUH – NISU – HNRC - ward facility

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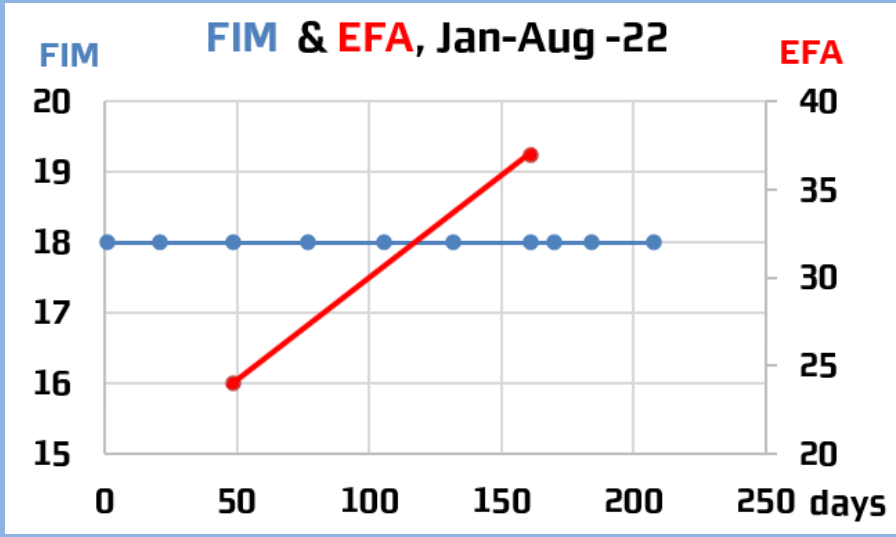
Medication
Metoprolol, Propranolol
Baclofen p.o., it.
Fentanyl, Morphine
Propofol
Clonidine
Clonazepam
Levetiracetam
Pimozid
Amantadine
Quetiapine
Zopiclone, Melatonin, Dexmedetomidine
Mirtazapin

Primary lesion:
MRC: hypoxic lesions, basal ganglia edematous, diffusion restriction
Clinical features
Circulation, respiration, metabolism, renal function **NAD**.
Paraclinical features
NSE 24, EEG abnormal, w/o epiletic seizures
Neurology
Susp myoclonus, dystonia (opisthotonus), paroxystic tachycardia, hypertonia,sweating, hypermetabolism, tachypnea ≡ **PSH.**
CRS-R
VS (Dec. 2021) ⇨ MCS (August 2022).



Therapeutic advance? PSH, HRV and Therapy

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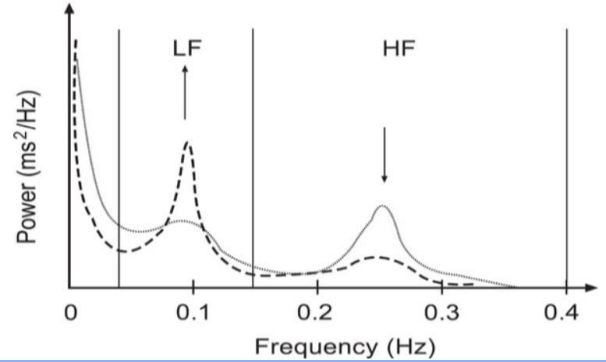
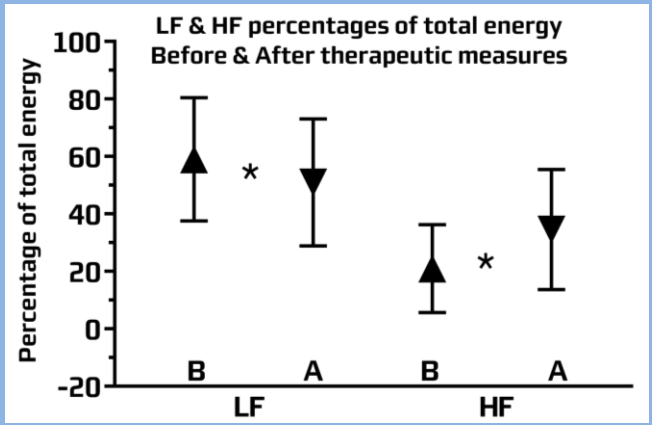
1)

Baguley: Clinical Feature Scale score				
Points	**0**	**1**	**2**	**3**
HR, min^{-1}	<100	100-119	120-139	≥140
RR, min^{-1}	<18	18-23	24-29	≥30
SBP, mmHg	<140	140-159	160-179	≥180
Tp, °C	<37	37-37.9	38-38.9	≥39.0
Sweating	absent	mild	moderate	severe
Hyperkinesis	absent	mild	moderate	severe

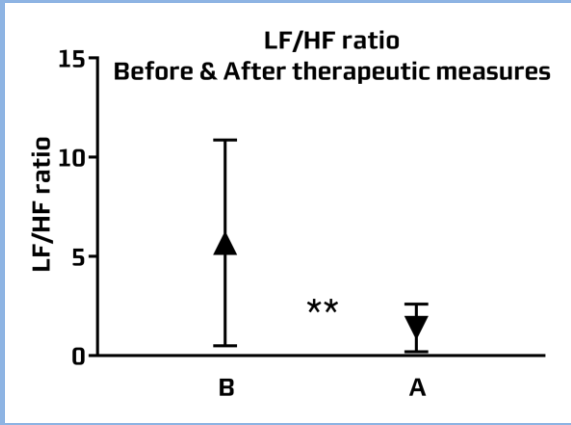
2)



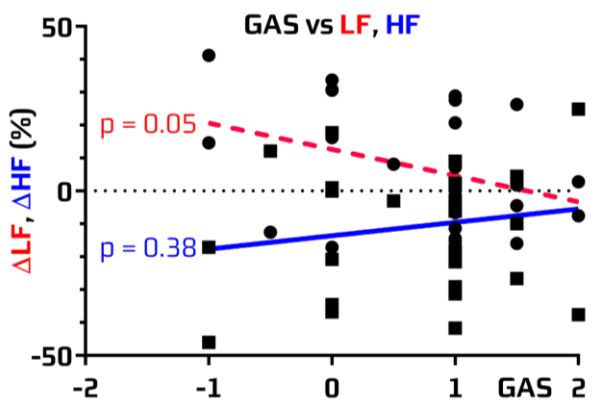
3) LF & HF Before & After Therapeutic session



4) LF/HF Before & After Therapeutic session



5) GAS vs LF & HF



H. Honoré, K. Eggertsen, S. Sondergaard. A study into the feasibility of using HRV variables to guide treatment in patients with PSH in a neurointensive step-down unit. NeuroRehabilitation DOI:10.3233/NRE-182557

Ethical issues in VS & MCS (I)

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What is
the diagnostic certainty? Physical examination, scoring systems, PET, fMRI (NB Bennett case for "multiple comparisons correction"[1])

What is
consciousness? ≡ "wakefulness & awareness of self and environment" instrumental to interactive social behaviour. MRI-supported decision making[2]?

What is "awareness of self and environment" and how do we rate it?
QoL ≡ perception of position in life in the context of the culture and value systems....
E.g., **AQoL-8D**: **Physical dimensions**: independent living, pain, senses. **Psychological dimensions**: happiness, mental health, coping, relationships, self worth.

How do prognostics in VS & MCS emerge? Prognostic tools are reflections of data limited to history, geography, medical expertise and past therapeutic goals. **ERGO: anachronistic on publication.**

Bias in prognostics? Therapeutic zeal and self-fulfilling prophecies: Do physicians inadvertently tailor treatment to idiosyncratic perceptions of good/bad prognosis?

What about the autonomy of the VS & MCS patient : Personal wishes? Surrogate's adherence to prior directives or assumed decision of sound mind? Surrogate **balancing the burdens and benefits** from continued treatment, and, implicitly, reducing the burden of dependency?

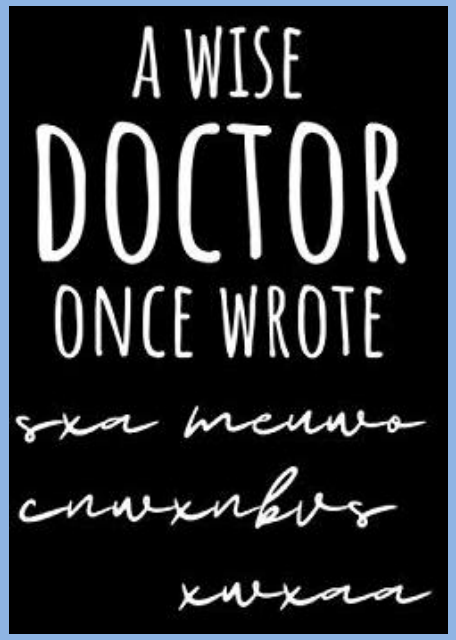
[1]C. Bennett, et al. Neural Correlates of Interspecies Perspective Taking in the Post-Mortem Atlantic Salmon. J. of Serendipitous and Unexpected Results. 1,1-5

[2]A. Peterson, et al. Unlocking the Voices of Patients with Severe Brain Injury. Neuroethics 2022 15,1, 1-15.

Task Force on PVS. Medical aspects of the persistent vegetative state. Parts I, II. NEJM 1994;330:1499-1508, 1572-1579

Ethical issues in neurology.
ed. J. L. Bernat. Lippincott Williams & Wilkins 2008.

Ethical issues in VS & MCS (II)



Others have added:

"...for to hope is to expect the possibility of the good, but the possibility of good is the eternal." S. Kierkegaard

"It takes more love to wish an end to an unfulfilling existence than to wish it maintained." Anonymous

"The grieving of lost opportunities in the life of a severely disabled relative may only effectively take its beginning at the relative's demise." The Hospital Vicar

Beware the predicament of a disabled relative as a '**social floating anchor**'
Humble Self

Kierkegaard, S., Swenson, DF & Swenson, LM 1949. Works of love, p.202 Princeton, N.J., Princeton University Press

Thank you for your attention

Survivors from the Malik storm February 22 arriving on an abandoned sandal

Slide 1:

Ladies and gentlemen! Thank you for the invitation to present the highly specialized rehabilitation of the neurointensive step down unit at Silkeborg Regional Hospital. The hospital is located in the central region of Jutland.

I've been working at the unit from 2015 and still regard myself as a newcomer to the field of neurorehabilitation. I have spent the greater part of my career at Gothenburg University Hospital, majoring in respiratory and cardiovascular monitoring and regulation. Bear with me if I'm not fully fluent in the vocabulary of the field.

After a general introduction to the organization and mission in the field of intensive care, I'll focus on the group of patients admitted to the department under the diagnoses of severity of cardiac arrest or anoxic brain damage arising from primary arrest or arrest arising from other causes e.g., strangulation, drowning or intoxication.

Slide 2:

NISU: The NISU is a link in the chain of treatments initiated at neurosurgical and neurointensive units at the University hospitals in the Western part of Denmark and the regional centres of rehabilitation and care facilities.

The patients admitted to NISU have completed their medical and surgical intensive care treatment to the point of minimal risk of complications arising. There may still be need of a light version of intensive care. Thus, we perform ventilatory therapy and measure invasive arterial pressure and the occasional pulse contour CO do occur in combination with vasopressors and inotropes.

At NISU the patients meet an interdisciplinary group of therapists, intensive care nurses and physicians. In addition, the unit is staffed with a social worker, speech therapist, neuropsychologist and secretary assistance. The therapists are shared with HNRC. NISU has immediate access to X-ray and biochemical departments and medical specialties in the hospital. Neurophysiology assistance is available for EEG from nearby Viborg Hospital. On weekly appointment a surgeon performs percutaneous gastroenterostomies (PEG). PDT is performed at the department, if not too complicated.

HNRC: When the intensive care is weaned and rehabilitation has the main focus, patients are "cleared" for transfer to Hammel Neurocentre. HNRC admits patients with acquired injuries to the central nervous system. HNRC also receives patients from medical and surgical wards to its 118 highly specialized and regional beds: in Hammel, Skive and Lemvig. More than 1100 patients are admitted and discharged annually and app. 1000 patients are treated on outpatient basis in six clinics. Neurorehabilitation is practised in four departments: Early

Rehabilitation, Cognitive disturbances, Sensorymotor disturbances and Infants and Adolescents. HNRC holds a research facility and a research professor as part of the University of Aarhus.

Slide 3:

As an intensivist, I have to look after the vital organs. One of my colleagues coined the heading “Keep the patient alive till the brain wakes up”. So, we'll have to look after the **CNS** to prevent secondary injury in the in the form of thrombosis, bleeding, hypoperfusion or hypoxia. **Dysphagia** is an obligatory henchman to ABI and we have to fend him off by securing the airway and frequently check the ability of the patient to swallow. Thus, we usually we establish a tracheostomy for the protection of the airway, while simultaneously weaning respiratory support via PS and PEEP. Regarding the **cardiovascular system**, we have to look after normalization of rhythm and frequency, regulation of flow and pressure. A major concern is volume versus tone. **Nutrition** is provided enterally after initial estimating equation of energy needs followed by indirect calorimetry. **Kidney function** is maintained by regulation of balances of fluids and electrolytes., Acid/Base status is analyzed in the Stewart algorithm, usually providing an explanation of the alkalosis in terms of low Hb and albumin. Above all, there is an **increased vigilance** towards changes in function of vital organs and a low threshold for registration of ECG, echocardiography, CTC, MRC and microbiological surveillance. We have frequent consultations with ancillary specialties, neuropsychology, psychiatry, infectious diseases, neurology, radiology, cardiology, et cetera, et cetera.

All pervasive is the **ethical considerations** when to withdraw and when to withhold life sustaining treatment. We thus have frequent consultations with next-of-kin with the aim of aligning expectations and hopes and realization of the clinical situation and prognostics.

Slide 4:

In 2015 the Regional Council, a political body, announced a strategy aiming at improving neurorehabilitation in patients surviving cardiac arrest. 1½ bed (a very political size of a bed) was allocated at NISU for this purpose and a number of projects were instigated conjoining forces of Aarhus University Hospital Centre of Functional Integrative Neuroscience, MRI departments at AUH and Silkeborg, Cardiothoracic Intensive Care, AUH, Cardiology AUH, HNRC and NISU.

To answer these ambitions representatives of the Cardiothoracic ICU and NISU issued a unified plan. After referral to NISU intensive care was continued as long as necessary and rehabilitation ran in parallel.

Slide 5:

I've been permitted to dig into the clinical databases for the past five years looking for data relating to patients with CA during. I haven't had the time to check the quality and veracity of the data, nor to explore connections and relationhips. Hopefully, though, they may also convey an impression of the subject.

Patients were primarily admitted to Aarhus University Hospital and transferred to NISU if the patient fulfilled the criteria enumerated previously. The following slides illustrate the numbers, survival rates and sex distribution at the three stations: AUH and NISU. Search criteria were the diagnoses cardiac arrest and anoxic brain damage.

Slide 6:

The data from AUH show a maximum incidence in in 7th and 8th decade and a median LOS of 8 days. Sex distribution demonstrates an absolute majority of males.

Slide 7:

As per plan only survivors arrive at NISU. Age distribution now shows a maximum in the 5th decade, presumably a reflection of the increased comorbidity in higher decades preventing them from referral. LOS has risen from 8 to 18.8 dd and sex distribution maintains the pattern of male dominance.

Slide 8:

As noted, the patients are examined regularly by clinically validated function scores. Arbitrarily, I have divided the measurements into three groups. About one third reach a level >50 in Functional Independence Measure without differentiating between motor and cognition subscales, nor the levels of Independence, Modified Dependence and Complete Dependence. The red thick line represents a smoothed mean. Registrations extend up to > 5 months. Further analyses should look into the relative distribution across the subscales.

Slide 9:

The group of FIM scores<50 seem to contain two subgroups: those quickly increasing FIM scores >25 and those hardly moving from minimal scores in the range 18 to 25. This slide truncates measurements around 7th month.

Slide 10:

This last slide illustrates the rather long rehabilitation period in a group of patients never achieving scores beyond 25. I'll leave it your personal considerations whether it makes sense to continue highly specialized rehabilitation for 7 months in a group of patients showing minimal progress….

Slide 11:

Just to illustrate the clinical course of one patient who may stand as a representative of a group of adolescents arriving at NISU with anoxic brain damage secondary to hypoxic cardiac arrest. This is a young man, somatically healthy, studying at Copenhagen Business School. He was physically active playing handball at a professional level. He spent a few months studying abroad but returned prematurely because not feeling well. Back in DK he experienced deteriorating psychic health and sought help from at a psychiatric accident and emergency unit which could not assist him further as he was not resident in the area. Days later he placed an emergency call announcing a premeditated attempt at suicide.

Police and ambulance arrived in less than 10 minutes, cut him down in 6 min. and established ROSC in 4 minutes. He was brought to AUH, LOS 18 dd, transferred to NISU, LOS 70 dd, transferred to HNC LOS 127 dd, a total exceeding 7 months. I have added his FIM and EFA scoring and part of his pharmacotherapy used to counter the dyskinesia and PSH.

Slide 12:

One of the studies connected to the allocation of a "CA-bed" in 2016 was an investigation using HRV in patients with PSH for assessing the effects on the sympathetic nervous system.

Fig. 1 is the Baguley table for the Clinical Feature Scale entering the assessment of PSH

Fig. 2 is a short explanation of the spectral components of the RR interval: During rest (dotted line) the PNS amplitude is prominent in HF. When position is shifted to tilt, the sympathetic peak increases (LF). Now, we measured ECG **Before** and **After** therapeutic sessions, analyzed the ECG in spectral terms, and

Fig 3. Shows the changes in relative power of sympathetic (LF) and parasympathetic power (HF) B and A therapy. Evidently, SNS diminished and PNS increased after the therapeutic session. Relative distribution of LF & HF before (B) and after (A) therapeutic interventions in PSH patients. Significant changes in percentages of LF & HF are seen in therapeutic measures. Sympathovagal balance is tipped towards less SNS activity.

Fig. 4 The changes are accentuated when expressed as the ratio between LF and HF.

Fig. 5 Lastly, the two therapists were asked to evaluate the results of their 30 sessions on a Goal Attainment Scale scoring the extent to which individual goals were achieved in the course of an intervention. The achievement of the goal is scored in five steps. There is a trend towards greater decrease in LF (predominantly SNS) and increase in HF (predominantly PNS) the better goals of intervention are achieved.

The perspective, of course, is the possibility of having an immediate assessment of the therapy expended on a patient. This can relatively easily be achieved if we managed to engage one of the companies producing monitors in neurointensive care.

Slide 13:

I would like to dedicate my last slides to the topic of ethics in the treatment of patients in VS and MCS. It's a sensitive subject as it exists between the field of the relatively "hard" science of medicine and the "soft" area of the highly personal outlook on life and death.

Why are we working in the medical field? For the benefit of whom? For our own gratification and curiosity or for the benefit of the patient, relatives and community? And what do we – or the autonomic patient – understand by benefit? Is it the demonstration of functional resting state networks enabling facilitated communication by placing the patient in the tube of an MRI apparatus or is it the possibility of interacting socially, perceiving and contributing to relationships in a couple, a group, a society?

I'm asking on the background of the **minute minority of survivors from CA who are at the centre of our efforts at the NISU.**

We are all reasonably familiar with the similarities and differences between VS and MCS. I'm asking the crude question: "If it were your uncle, your aunt, your father, mother, son, or daughter being diagnosed with VS or MCS, would you prefer the 24/7/365 care necessary for your loved one?"

It's a provocative question but none the less often commented upon by next-of-kin of patients in NISU – and we ask the question!

A number of issues come to mind when discussing ethical issues surrounding the care of patients diagnosed as in VS or MCS. I have prepared a selection. You may want to add other questions, please feel free to do so. I'm all ears.

Slide 14:

Apart from the questions related to the professional issues of diagnostics, treatment and prognostics, the ethical issues have been expressed in various ways stretching from the inane to the incomprehensible. Admittedly, I find it difficult to get a grip on the topic and maybe it's better left to individual deliberations in the setting of beliefs, culture and religion.