Brain Injury
MedTech Co-operative

NHS
National Institute for Health Research

Intracranial Dynamics and Shunt Technology

MIC Theme 4

Professor Marek Czosnyka & Dr Peter Smielewski

Background

Intracranial Dynamics & Shunt Technology

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Intracranial dynamics focuses on the mechanisms and models of the blood supply to the brain and its buoyancy mechanisms. How do changes in cerebral blood flow (CBF) and the cerebrospinal fluid (CSF) circulation interact in time and in space and how may stable flows and fluxes be preserved over a wide range of compartmental pressures within the brain? How do such control systems change with brain injury and how may such disturbances be ameliorated?

Cerebral autoregulation (CA) controls and adapts cerebral blood flow (CBF) over a range of cerebral perfusion pressures (arterial blood pressure minus intracranial pressure) thereby ensuring adequate perfusion and oxygenation of the brain. This crucial neuroprotective mechanism provides the haemodynamic reserve to cope with various insults is variably impaired following acute brain injury in newborn infants, children and adults, and is an independent predictor of poor outcome.

Significant advances in TBI outcome have been achieved over the last 20 years by basing our management of systemic and cerebrovascular physiology on targets derived from population studies. However, this approach takes no account of interpatient heterogeneity as reflected by varying degrees of autoregulatory reserve in different patients and its time-variability. There is mounting evidence that including cerebral autoregulation in the ICU management of patients after severe TBI is beneficial to patients' survival and generally better outcome.

Autoregulation based individualisation of therapy thresholds has been included in the recent brain trauma guidelines. However there are still no clinically approved monitors of cerebral autoregulation available.

Crucial to such studies has been the development of techniques for the continuous monitoring of cerebrovascular reactivity [Czosnyka M, *Stroke* 1996] and cerebral autoregulation [Czosnyka M, *Neurosurgery* 1997]. These novel methods, based on computer-supported time-series analysis were introduced in 1996-1997 and have demonstrated such methods can be beneficial in the acute stage of management of TBI patients for the individual optimization of management strategies. This work led to the development of the concept of defining an individual patient's 'Optimal Cerebral Perfusion Pressure' using continuous monitoring of a dynamic index of cerebral autoregulation [Steiner L *Critical Care Medicine* 1997] – until this work, patients were assumed to require the same cerebral perfusion pressure.

Strategy

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Year 1 **Short-term**	A new method based on combined measurements of optic nerve sheath diameter and venous Doppler blood flow velocity will be validated against invasive monitoring of ICP Computing tools for targeted management of CPP in TBI patients will be developed for ICM+ software Cambridge Shunt Evaluation Laboratory - assessment of the Certas 2 valve A monitoring cart will be designed for non-ivasive brain monitoring, containing TCD ultrasonograph, plethysmographic arterial blood pressure monitor and profiled custom version of ICM+ to assess multiple parameters of brain circulation, including autoregulation, critical closing pressure, diastolic closing margin, and baraoreflex sensitivity
Year 2-3 **Medium - term**	Near infrared Spectroscopy will be added to the cart to facilitate assessment of ‘optimal’ arterial blood pressure target A multicenter RCT is planned to assess the efficacy of the ‘optimal CPP’ approach to management of TBI
Year 4-5 **Long-term**	Creation of a comprehensive multimedia support to improve dissemination of the knowledgebase pertaining to the CSF dynamics investigatigative suite of tools implemented in ICM+. This will be made available on-line via a new, redesigned ICM+ web portal. Diffuse Correlation Spectroscopy is a new technique using near infrared light, able to monitor CBF in absolute units (ml/min/100g). We plan to add and validate DCS using the non-invasive brain monitoring platform Continuation of ‘optimal CPP’ trial.

Sub-themes

Intracranial Dynamics & Shunt Technology

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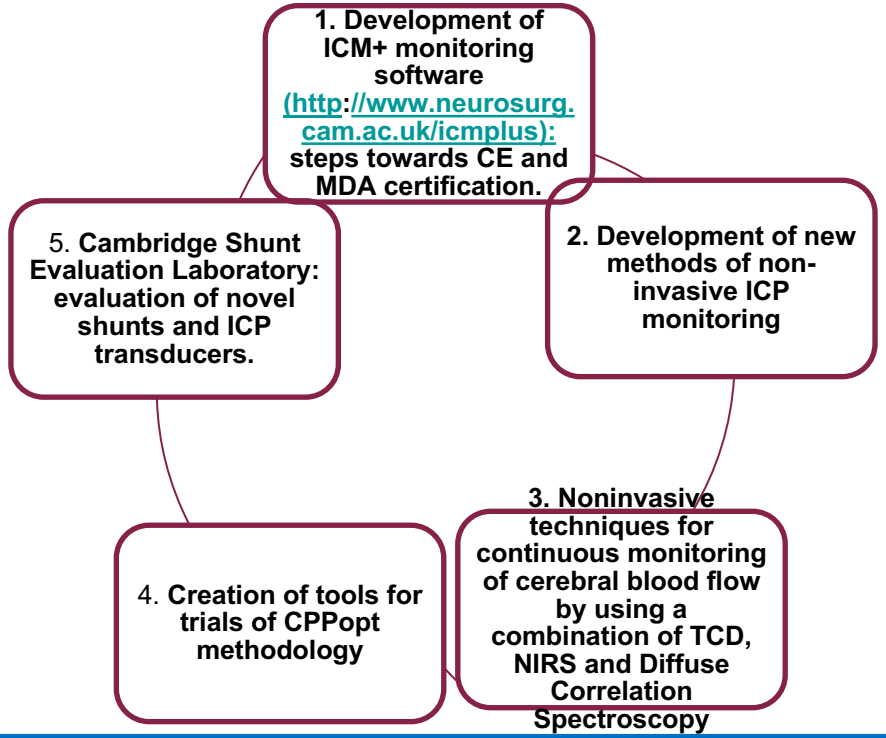


FIND

Identify areas of unmet need throughout the brain injury pathway that might be amenable to a technology-based innovation.

FACILITATE

Promote the generation of innovative solutions through the facilitation of interdisciplinary communication and collaboration between the NHS, academia, industry and public organisations.

FOSTER

Support the translational pathway of viable solutions from initial concept to successful market adoption and sustainable clinical impact.

CORE ACTIVITIES: Patient & Public Involvement, MedTech Regulation & Developmental Support, Clinical Informatics, Health Economics

BRAIN INJURY PATIENT PATHWAY

- Prehospital Care
- Neurocritical Care
  - Multimodality Bedside Monitoring
  - Intracranial Dynamics
  - Functional Neuroimaging / Neurophysiology
- Neuro-Oncology
- Regenerative Neuroscience
- Neurorehabilitation
  - Cognition & Mental Health
  - Neuropsychological Rehabilitation
- Neuro-development/Paediatrics
- Old Age
- Reintegration into the Community
- Prevention

Identification of unmet need

Proactive

1. Horizon scanning
2. Road mapping
3. Gap analysis
4. Competition

Reactive

1. NIHR clinical research infrastructure (NOCRI)
2. National Institute for Health and Care Excellence (NICE)
3. Surgical Technology Evaluation Portal (STEP)

Triage

Sense check

1. Validate need
2. Market analysis/Health economics
3. Technology screen
4. Intellectual Property Rights
5. Regulatory issues
6. Peer review

Catalyse early R&D

1. Inform competitions
2. Pump priming
3. Team building
4. Identification of networks
5. Grant application
6. Industrial partnership

Catalyse early Proof of Concept

1. Inform competitions
2. Pump priming
3. Team building
4. Identification of networks
5. Prototype
6. CE marking
7. Grant application
8. Industrial partnership

Growth

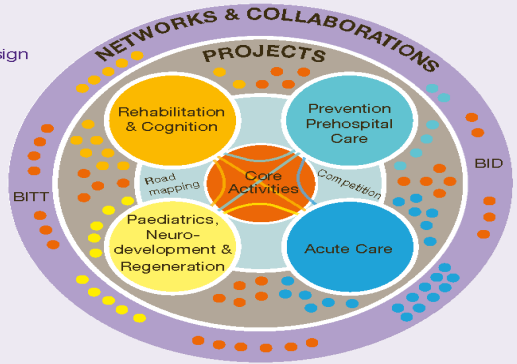
1. Linkages to funding initiatives
2. Crowd sourcing
3. Source investment
4. Support grant applications
5. Experimental clinical research (phase 0 to II)
6. Inform Randomized Controlled Trial Design (phase III)

Evaluation

1. Brain Injury Den (BID)
2. Brain Injury Technologies Think tank (BITT)
3. Expert review

Handover, dissemination & early adoption

1. NICE evaluation
2. Revision of clinical pathway
3. Publications and presentations
4. Wider innovation landscape
5. Industrial development



Clinical Themes

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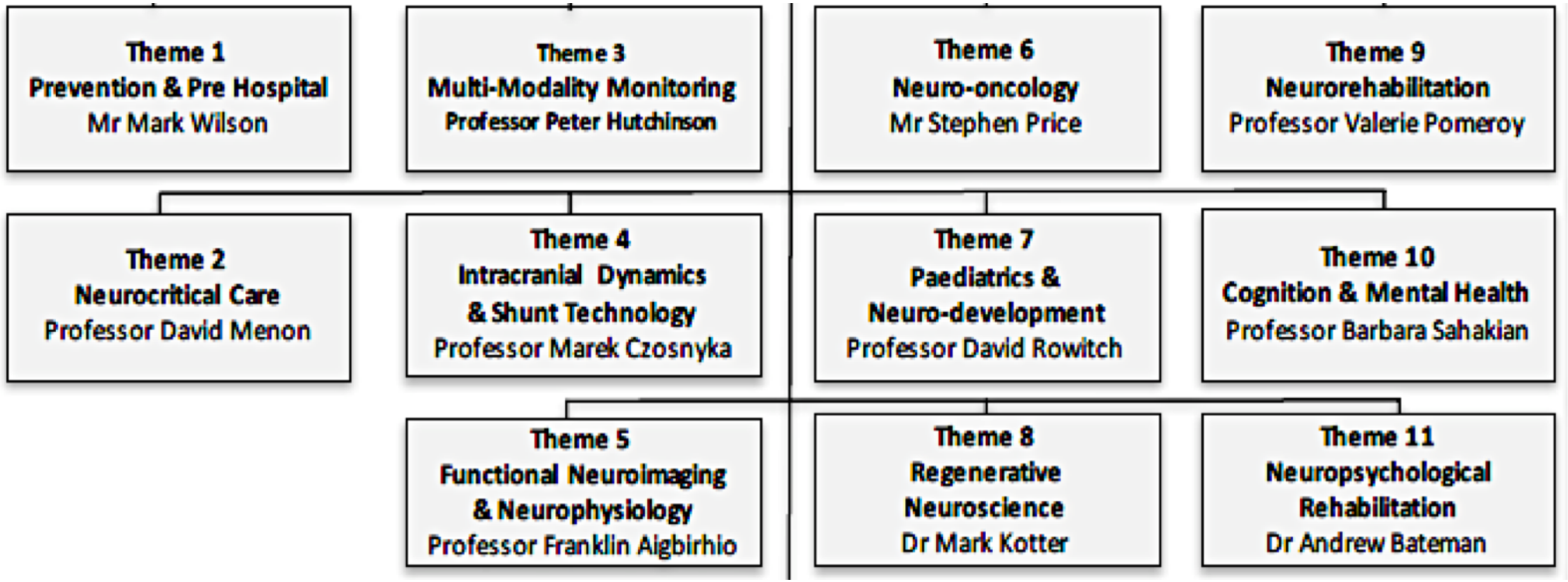

Healthcare Technology Co-operative (2013-2017)

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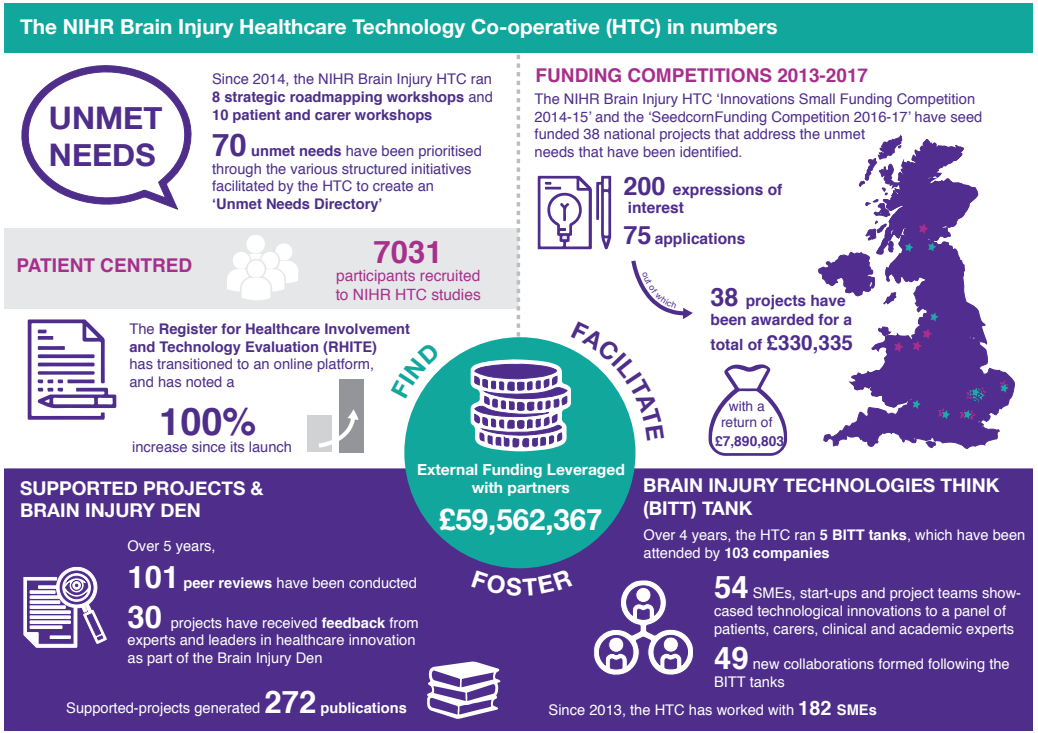

Pathway Mapping

Acute Care & Monitoring

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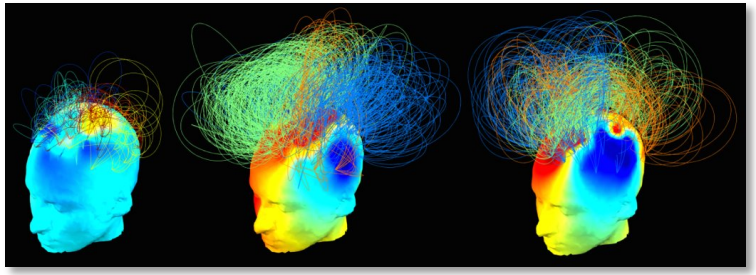
Brain network visualisation and assessment at the bedside in disorders of consciousness

Dr Srivas Chennu



VS Patient | VS Patient | Healthy adult

Healthy adults

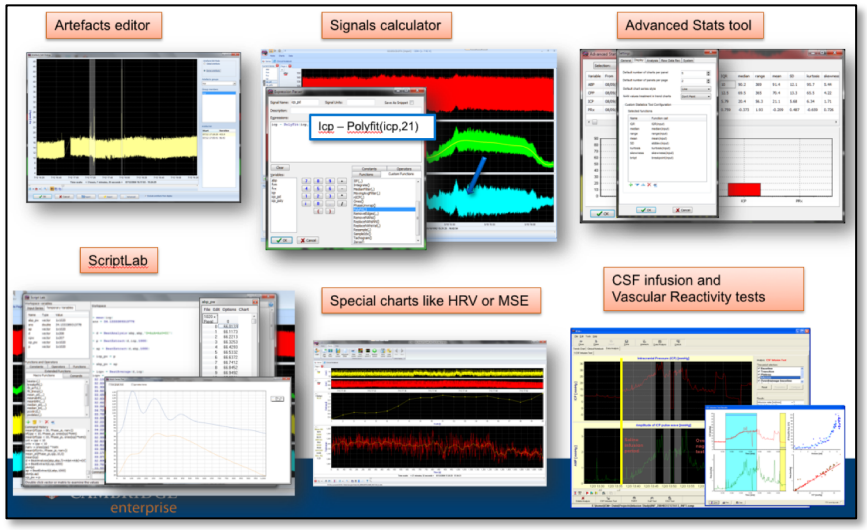
MCS

VS

ICM+

Dr Peter Smielewski, Brain Physics, University of Cambridge

https://icmplus.neurosurg.cam.ac.uk



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The Next Generation

Launch Event

Wednesday 25 April 2018: Homerton College, CB2