(03)

維持腦部健康：全手術期照護團隊的關鍵行動

Maintaining Brain Health: Key Actions for the Perioperative Care Team

時　　間：115 年 6 月 27 日(星期六) 08:20~12:00
地　　點：臺北榮民總醫院 致德樓第三會議室
主　　辦：中華醫學會、臺北榮總麻醉部
合　　辦：國立陽明交通大學急重症研究所

08:20-08:30	***Opening Remarks***	王署君副院長 Shuu-Jiun Wang 程廣義理事長 Kuang-I Cheng
08:30-08:35	大腦安全倡議 Safe Brain Initiative (SBI)	丁乾坤主任 Chien-Kun Ting
	座長：葉育彰 醫師 (Yu-Chang Yeh)	
08:35-09:00	SBI 總論：願景與 18 項核心建議 From index to Insight- Clinical Perspectives on Electroencephalographic Spectrogram-Guided Anesthesia	吳峻宇主任 Chun-Yu Wu
	座長：曹正明 主任 (Cheng-Ming Tsao)	
09:00-09:25	如何維持腦部健康？手術當中的腦血氧監測 Perioperative Brain Health: Cerebral Oximetry Monitoring	張詒婷醫師 Yi-Ting Chang
	座長：徐永偉 主任 (Yung-Wei Hsu)	
09:25-09:50	EEG Bootcamp (一)：原始波形 (Raw EEG) 的判讀藝術 EEG Bootcamp (I): The Art of Interpreting Raw Electroencephalogram	王資峻醫師 Tzu-Chun Wang
09:50-10:20	***Coffee Break***	
	座長：陳貞吟 主任 (Jen-Yin Chen)	
10:20-10:45	術中腦電圖監測與密度頻譜陣列：精準麻醉調控的臨床實踐框架 Intraoperative EEG Monitoring Using the Density Spectral Array: A Practical Framework for Precision Anesthetic Control	何淳寧醫師 Chun-Ning Ho

座長：楊智傑 醫師 (Chih-Chieh Yang)

10:45-11:10	SBI System (Muda & Us)：系統效率與醫師福祉 SBI System (Muda & Us): System Efficiency and Physician Well-being	鄧惟濃主任 Wei-Nung Teng

座長：林素滿 主任 (Su-Man Lin)

11:10-11:35	實踐與行動：建立 Safe Brain 醫院生態系 Practice and Implementation: Establishing a Safe Brain Hospital Ecosystem	黃博御醫師 Po-Yu Huang

座長：林世斌 主任 (Shih-Pin Lin)

11:35-12:00	實踐與行動：建立 Safe Brain 診所生態系 Implementation and Action: Building the Safe Brain Ecosystem in Private Clinics	蘇百川醫師 Bai Chuan Su
12:00-12:10	***Closing Remarks***	丁乾坤主任 Chien-Kun Ting

From index to insight- clinical perspectives on electroencephalographic spectrogram-guided anesthesia

SBI 總論：願景與 18 項核心建議

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With the development of anesthesia techniques, electroencephalography (EEG) monitoring is gradually shifting from relying on single-valued “processed EEG indices” (such as the bispectral index BIS) to more physiologically meaningful “EG spectrograms” (such as DSA) to guide anesthesia. While processed EEG indices simplify the interpretation of anesthesia depth, their algorithms are opaque and easily affected by electromyography (EMG) interference, surgical electrical noise, or the effects of anesthetic drugs with different pharmacological properties (such as ketamine and dexmedetomidine), leading to inaccurate values. Furthermore, the accuracy of these indices decreases significantly in elderly or pediatric patients. In contrast, DSA preserves the complete frequency and temporal structure of brain waves, providing three major advantages for clinical anesthesia:

1. Assessing brain health and preventing postoperative delirium: DSA can instantly present the intensity of frontal lobe alpha waves, reflecting the stability of the cortical network. Maintaining sufficient alpha waves can significantly reduce the risk of neurocognitive complications such as postoperative delirium (POD).
2. Precise Detection of Painful Stimuli: DSA can identify specific patterns of pain caused by harmful stimuli (such as alpha dropout, beta arousal, or delta arousal, which is easily misinterpreted as “deepening anesthesia” by general indices), assisting physicians in administering analgesics more accurately.
3. Improved Safety of Multimodal and Age-Specific Anesthesia: DSA can easily identify and eliminate high-frequency noise interference, avoiding false elevations in indices.
4. Furthermore, it can provide more accurate personalized anesthesia dosage guidance for elderly and pediatric patients whose brainwave patterns change with age.

In summary, although the widespread adoption of DSA still requires the establishment of standardized quantitative indicators and structured education and training, it has successfully elevated anesthesia monitoring from rigid algorithmic numerical values to a profound understanding of brain neurophysiology, representing a key advancement in achieving personalized and brain-protective anesthesia.

Perioperative brain health: Cerebral oximetry monitoring

如何維持腦部健康？手術當中的腦血氧監測

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Preserving perioperative brain health hinges on real-time insight into cerebral perfusion, and near-infrared spectroscopy (NIRS) remains the most accessible bedside tool to provide it. Between 2020 and 2026, NIRS has evolved from a niche cerebral oxygenation monitor into a versatile platform that informs cardiac, somatic, and multi-modal neuromonitoring decisions. This 15-minute lecture frames that evolution around four practical questions every anesthesiologist now faces, integrating recent guidelines (ERAS-USA 2020, EACTS/EACTAIC/EBCP 2024) with emerging RCT and observational data.

For cardiac surgery, NIRS remains anchored by two principles: pre-induction baseline (Strong, LOE B) and algorithm-guided intervention (Class IIa, Level B). Two 2025–2026 applications expand its role beyond established use: NIRS as an early warning of low cardiac output syndrome, where rSO_2 drops >20% precede a fall in cardiac index (Silaschi 2025, AUROC 0.99); and individualized cerebral autoregulation–based MAP targeting in the ongoing PRECISION trial (Gomes 2026). In non-cardiac surgery, the Bieze 2025 algorithm RCT shortened desaturation time from 23 to 9 minutes but did not improve outcomes, reinforcing a "safety net," risk-stratified rather than routine, approach.

Adult renal NIRS fails because the renal cortex sits 4.6 cm beneath the skin, well outside the 2–2.5 cm penetration depth of clinical sensors — what is measured is subcutaneous fat and back muscle. Limb and somatic NIRS, in contrast, fall squarely within this depth and have demonstrated value across six clinical scenarios: VA-ECMO distal perfusion (where routine NIRS reduced surgical limb ischemia from 8.5% to 2.6%; Vinogradsky 2023), TAAA paraspinous monitoring, PAD severity assessment and post-endovascular prognosis, free-flap surveillance, and compartment syndrome.

Looking forward, multi-modal integration is the frontier: NIRS plus EEG identifies the cognitively fragile brain through reduced spectral edge frequency (Behera 2026) and predicts return of spontaneous circulation during prolonged CPR via alpha-wave reappearance under maintained rSO_2 (Huppert 2026, OR 5.4). A six-pillar mental model — baseline-anchored, algorithm-guided, multi-modal, context-aware, individualized, and limb-aware — summarizes how to read NIRS in 2026. The take-home: NIRS is not a single number, it is a safety net for perioperative brain health.

The art of interpreting raw electroencephalogram
原始波形 (Raw EEG) 的判讀藝術

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In contemporary clinical anesthesia, the Electroencephalogram (EEG) has emerged as a cornerstone tool for monitoring anesthetic depth and safeguarding perioperative brain health. However, an over-reliance on single-value processed EEG indices (such as BIS or PSI) often leads to clinical misinterpretation. These algorithms may filter out vital physiological information or produce misleading values when confronted with specific pharmacological agents or signal interference. Therefore, returning to the characteristics of the Raw EEG and mastering the significance of various parameters is essential to truly grasp the "art of diagnosis" regarding a patient's brain state.

To move beyond single-parameter analysis, establishing a standardized workflow for waveform observation is a clinically viable approach. First, we must understand the frequency, amplitude, and specific patterns of EEG waveforms under anesthesia. The initial step in interpretation is the identification of artifacts—such as electromyography (EMG) interference, surgical noise, or electrocardiogram (ECG) contamination—which can distort signals and lead to bias.

Next, clinicians must recognize the signatures of a stable anesthetic state, characterized by Alpha oscillations and Slow-delta waves. Furthermore, it is crucial to understand the specific patterns triggered by various clinical factors: for instance, the correlation between burst suppression and excessive anesthetic depth or cerebral ischemia, and how Alpha dropout or Delta arousal serves as indicators of nociceptive (pain) stimuli.

By mastering the identification of raw waveform characteristics, the anesthesia team can effectively distinguish true physiological signals from technical interference. This expertise enables more precise, evidence-based clinical decisions, ensuring the neurological safety and long-term brain health of patients during surgery.

Intraoperative EEG monitoring using the density spectral array: A practical framework for precision anesthetic control

術中腦電圖監測與密度頻譜陣列：精準麻醉調控的臨床實踐框架

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Intraoperative electroencephalography (EEG) monitoring has evolved beyond simple depth-of-anesthesia indices toward nuanced, pattern-based interpretation of brain state. The Density Spectral Array (DSA) — a color-coded time-frequency heatmap derived from fast Fourier transform (FFT) analysis of frontal EEG — enables anesthesiologists to visualize 20 minutes of continuous spectral data at a glance, revealing anesthetic depth, drug-specific signatures, and pathological patterns that single-number indices may obscure.

This lecture presents a structured four-module framework for interpreting DSA in clinical practice. The first module establishes DSA fundamentals: each anesthetic agent produces a distinct spectral fingerprint, and patient variables, including age and systemic illness, modulate these signatures. The second module addresses burst suppression (BS), defined by isoelectric EEG alternating with high-amplitude bursts — a manifestation of neuronal metabolic exhaustion mediated by ATP-sensitive potassium channel activation rather than a marker of adequate anesthetic depth. Commercial monitors (BIS, GE Entropy, SedLine) differ in their BS detection algorithms and consistently underestimate true suppression burden; intraoperative BS is associated with a 41% relative increase in postoperative delirium risk. The third module reframes frontal alpha dropout: abrupt loss of the 8–13 Hz alpha band during stable anesthesia reflects nociceptive thalamocortical breakthrough requiring opioid administration, not anesthetic deepening. The fourth module integrates DSA with near-infrared spectroscopy (NIRS) through a clinical 2×2 decision matrix: concurrent EEG suppression and rSO_2 decline (≥20% from baseline) mandates hemodynamic intervention for cerebral ischemia, whereas isolated EEG suppression with stable rSO_2 identifies excessive anesthetic depth requiring drug reduction.

By conceptualizing DSA as the brain's tachometer and NIRS as its fuel gauge, clinicians can integrate these complementary modalities into a unified real-time framework for precision anesthetic control, with direct implications for reducing perioperative neurocognitive complications.

SBI system (Muda & Us): System efficiency and physician well-being

SBI system (Muda & Us)：系統效率與醫師福祉

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Safe Brain Initiative (SBI) is not only about applying brain monitoring technologies such as EEG, DSA, or cerebral oximetry. Its deeper value lies in transforming perioperative care into a safer, more efficient, and more sustainable system. Within this framework, Muda and Us represent two essential system-level perspectives: reducing waste in clinical workflows and protecting the well-being of physicians and care teams.

Muda, a Lean concept meaning waste, refers to processes that consume time, energy, and resources without adding value to patient care. In perioperative practice, Muda may appear as delayed first-case starts, prolonged fasting, incomplete preoperative information, repeated documentation, inefficient turnover, missing equipment, fragmented handovers, or unnecessary waiting in the PACU. These problems are often treated as operational inconveniences, but from the SBI perspective, they directly affect brain safety. Waste increases patient anxiety, extends fasting time, creates time pressure, raises cognitive load, and reduces the ability of clinicians to interpret brain monitoring signals and respond appropriately.

Us focuses on the people within the system: physicians, nurses, anesthesiologists, surgeons, and all perioperative team members. Physician well-being should not be understood merely as personal resilience or stress management. It is a core patient safety infrastructure. A system that repeatedly exposes clinicians to fatigue, interruptions, unclear communication, time pressure, and excessive administrative burden cannot reliably deliver high-quality brain-protective care.

The goal of SBI System is therefore to connect efficiency, brain safety, and team well-being through measurable feedback. A practical Safe Brain dashboard may include operating room delay, PACU stay, fasting duration, delirium screening, EEG or NIRS events, postoperative pain, patient-reported outcomes, workload, overtime, and team perception of care quality.

The central message is simple: we cannot build a Safe Brain hospital with an unsafe work system. To protect the patient’s brain, we must also protect the system and the people who deliver care.

Practice and implementation: Establishing a safe brain hospital ecosystem

實踐與行動：建立 Safe Brain 醫院生態系

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The Safe Brain Initiative (SBI) represents a paradigm shift in perioperative care, moving beyond traditional vital signs to actively monitor and protect organ function, specifically the brain. While technical proficiency in interpreting tools like Near-Infrared Spectroscopy (NIRS) and processed Electroencephalography (pEEG) is crucial, the ultimate success of brain protection lies in the systematic integration of these technologies into daily clinical practice. This presentation outlines the structured implementation and actionable steps required to establish a comprehensive "Safe Brain Hospital Ecosystem."

Transitioning from individual monitoring to an institutional ecosystem demands a multidisciplinary approach and robust change management. We discuss the design of clinical care bundles and standardized workflows that seamlessly embed multimodal neuromonitoring into the routine anesthetic management of high-risk surgical patients. A critical component of this ecosystem is the elimination of clinical inefficiencies, or "Muda," by streamlining communication across different perioperative teams, including the surgical, PACU, and ICU teams. Furthermore, leveraging data-driven insights from real-time objective monitoring allows for proactive rather than reactive clinical interventions.

Ultimately, establishing a Safe Brain ecosystem is not merely a technological upgrade but an institutional quality improvement project. This session will share practical clinical experiences, implementation strategies, and preliminary outcomes focused on reducing postoperative neurocognitive disorders, minimizing hospital length of stay, and enhancing healthcare provider well-being. By fostering a culture of collaborative brain health preservation, we can scale these clinical practices to ensure optimal patient safety and sustainable clinical excellence across healthcare institutions.

Implementation and action: Building the safe brain ecosystem in private clinics

實踐與行動：建立診所 Safe Brain 生態系

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The STARDUST Anesthesia Team is dedicated to providing high-quality, safe care for clinics. Our current anesthetic services cover pediatric dental sedation, adult dental sedation, microtia surgery, plastic surgery, and full-face lifts, spanning a patient demographic aged 2 to 80 years.

In recent years, a primary focus of our care has been how to implement brain protection concurrently during anesthesia. In this presentation, we will share our team's current clinical experience and practical applications of the **Safe Brain Initiative (SBI) Care Bundle** in clinic-based anesthesia and sedation care. Furthermore, we will discuss the potential challenges encountered across our different surgical patient populations.