1

Whyから始める「脳波モニタ」

- 麻酔中の脳波モニタはなぜ重要か? – **Why?**
- 脳波モニタの最近の話題は何か？-**What?**

2

Whyから始める「脳波モニタ」

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3

麻酔中の脳波モニターはなぜ重要か？

Part 1

術中覚醒を避けるため

Kumamoto University

4

術中覚醒はPTSDを引き起こすと言われるが…

P: B-Aware trial (n=2,463) [Myles PS, et al. Lancet 2004]の患者

E: 術中覚醒患者（n=7）

C: 上記術中覚醒患者と手術日時, 年齢, 術式, 施設が同一である患者（n=25）

O: 主要評価項目：PTSD発生率

- ✓ 術中覚醒患者は13名いたが, 本研究時点で生存していた患者は7名.
- ✓ 2006-2007年にデータ収集し, フォロー期間 5.3年 [4.3-5.7].
- ✓ 術中覚醒以外の要因がPTSDと関与している可能性を調べるため, 術中覚醒患者1名に対して3-4名のコントロール患者を設定

Anesth Analg 2010; 110: 823-8

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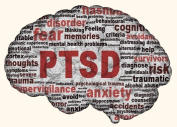
術中覚醒 👉 PTSD



- ✓ Reexperiencing symptoms（再体験）
- ✓ Avoidance and numbing symptoms（回避・麻痺症状）
- ✓ Hyperarousal symptoms（過覚醒）

- ✓ 術中覚醒患者 7名中 5名 (71%) がPTSDと診断
- ✓ コントロール患者 25名中 3名（12%）がPTSDと診断
- ✓ 術中覚醒はPTSDの要因である.（補正OR 13.3 [95%CI: 1.4-650])
- ✓ PTSD症状の始まり： 術後14日 [7-232 日]
- ✓ 症状の持続期間：4.7年 [4.4 – 5.6年]

Kumamoto University

Anesth Analg 2010; 110: 823-8

6

術中覚醒の発生率

PERIOPERATIVE MEDICINE

Prevention of Intraoperative Awareness with Explicit Recall in an Unselected Surgical Population

A Randomized Comparative Effectiveness Trial

George A. Mashour, M.D., Ph.D.,* Amy Shanks, M.S.,†
Kevin K. Tremper, Ph.D., M.D.,‡ Sachin Kheterpal, M.D., M.B.A.,§
Christopher R. Turner, M.D., Ph.D., M.B.A.,‖ Satya Krishna Ramachandran, M.D., F.R.C.A.,§
Paul Picton, M.D., F.R.C.A.,§ Christa Schueller, B.S.,# Michelle Morris, M.S.,**
John C. Vandervest, B.S.,†† Nan Lin, Ph.D.,‡‡ Michael S. Avidan, M.B., B.Ch.§§

Kumamoto University

Anesthesiology 2012; 117: 717-25

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術中覚醒の発生率

P: 全身麻酔患者: ミシガン大学病院他3施設, RCT

I: BIS>60で警告が出る術中管理 （n = 9,460）

C: Age-adjusted MAC<0.5で警告が出る術中管理 (n = 9,346)

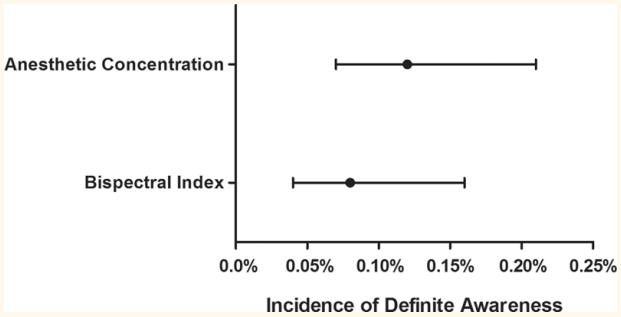
O: 主要評価項目：術中覚醒発生率

*麻酔方法はプロポフォール導入, 維持は吸入麻酔を基本とする

Anesthesiology 2012; 117: 717-25

8

術中覚醒の発生率



No significant difference in intraoperative awareness with explicit recall was detected between bispectral index and anesthetic concentration protocols (0.08 vs. 0.12%, P=0.48)

Anesthesiology 2012; 117: 717-25

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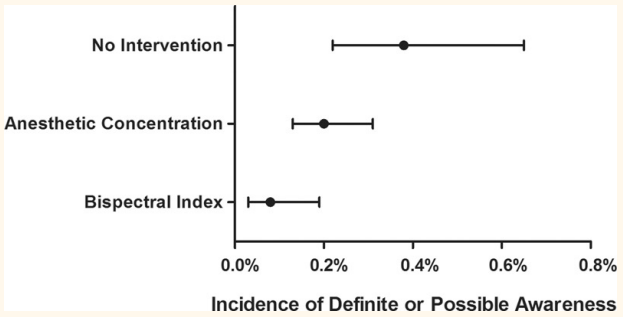
術中覚醒の発生率



The BIS protocol was associated with a 4.7-fold reduction in definite or possible awareness events compared with a cohort receiving no intervention (P = 0.001; 95% CI: 1.7-13.1).

Anesthesiology 2012; 117: 717-25

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麻酔中の脳波モニターはなぜ重要か？

Part 2

深鎮静を避けるため

Kumamoto University

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深鎮静 👉 覚醒遅延・術後脳機能障害

Intraoperative Electroencephalogram Suppression Predicts Postoperative Delirium

Bradley A. Fritz, MD,* Philip L. Kalarickal, MD,* Hannah R. Maybrier, BS,* Maxwell R. Muench, BS,* Doug Dearth, MD,* Yulong Chen, BA,* Krisztina E. Escallier, MD,* Arbi Ben Abdallah, PhD,* Nan Lin, PhD,† and Michael S. Avidan, MBBCh*

Kumamoto University

Anesth Analg 2016; 122: 234-42

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深鎮静と術後せん妄

P: ICU入室予定の全身麻酔患者 (n = 727) : Barnes-Jewish Hospital

E: EEG suppression, BISを記録

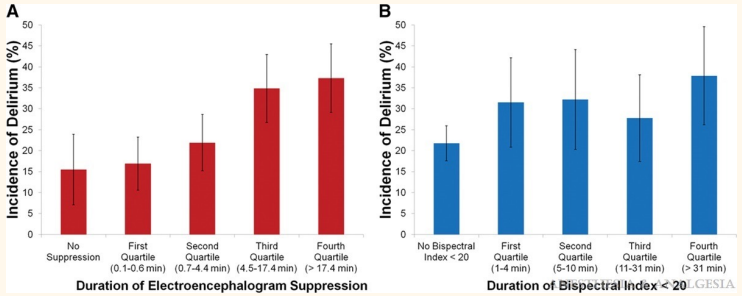
O: 主要評価項目：術後5日間のせん妄発生

Confusion Assessment Method for the intensive care unit

Anesth Analg 2016; 122: 234-42

13

EEG suppressionと術後せん妄



This effect remained significant after we adjusted for potential confounders (Odds ratio for log(EEG suppression) 1.22 [99% CI, 1.06–1.40, P = 0.0002] per 1-minute increase in suppression).

Anesth Analg 2016; 122: 234-42

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脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？

JAMA | Original Investigation

Effect of Electroencephalography-Guided Anesthetic Administration on Postoperative Delirium Among Older Adults Undergoing Major Surgery
The ENGAGES Randomized Clinical Trial

Troy S. Wildes, MD; Angela M. Mickle, MS; Arbi Ben Abdallah, PhD; Hannah R. Maybrier, BS; Jordan Oberhaus, BS; Thaddeus P. Budelier, MD, MSF; Alex Kronzer, BA; Sherry L. McKinnon, BS; Daniel Park, BS; Brian A. Torres, DNP; Thomas J. Graetz, MD; Daniel A. Emmert, MD, PhD; Ben J. Palanca, MD, PhD; Shreya Goswami, MBBS, DNB; Katherine Jordan, BS; Nan Lin, PhD; Bradley A. Fritz, MD; Tracey W. Stevens, MD; Eric Jacobsohn, MBChB, MPHE, FRCPC; Eva M. Schmitt, PhD; Sharon K. Inouye, MD, MPH; Susan Stark, PhD; Eric J. Lenze, MD; Michael S. Avidan, MBBCh; for the ENGAGES Research Group

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Wildes TS, et al. JAMA 2019; 32: 473-483

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脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？

- Randomized clinical trial of 1,232 adults aged > 60 undergoing major surgery
- EEG-guided anesthesia (n= 614) and usual anesthetic care (n = 618)
- Primary outcome: The incidence of delirium postoperative days 1 through 5.

Intraoperative measures	EEG guided	Usual care	
Duration of anesthesia, min	264.5 (192 to 344)	264.0 (186 to 349)	0.5 (−16.7 to 16.7)
End-tidal volatile agent concentration, MAC[d]	0.69 (0.62 to 0.77)	0.80 (0.71 to 0.86)	−0.11 (−0.13 to −0.10)
Duration of BIS <40, min[e]	32 (9 to 81)	60 (19 to 132)	−28 (−38.0 to −18.0)
Time with SR >1%, min[f]	7 (1 to 23)	13 (2 to 58)	−6 (−9.9 to −2.1)
MAP, mean (SD), mm Hg	81.2 (8.26)	79.6 (7.68)	1.5 (0.63 to 2.42)
Duration of MAP <60 mm Hg, min	7 (2 to 19)	7 (1 to 19)	0 (−1.7 to 1.7)

The overall median differences between the randomization groups in times with EEG suppression and BIS <40 were significant (P < .001).

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Wildes TS, et al. JAMA 2019; 32: 473-483

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脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？

Table 3. Primary and Exploratory Outcomes and Adverse Events

Outcome Category	No./Total No. (%) Guided	Usual Care	Difference, % (95% CI)[a]	*P* Value[b]
Primary outcome				
Overall delirium incidence[c]	157/604 (26.0)	140/609 (23.0)	3.0 (−2.0 to 8.0)	.22

*EEG-guided anesthetic administration, compared with usual care, **DID NOT** decrease the incidence of postoperative delirium.*

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Wildes TS, et al. JAMA 2019; 32: 473-483

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脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？

Geriatric Anesthesia

META ANALYSIS

Electroencephalography-Guided Anesthetic Delivery for Preventing Postoperative Delirium in Adults: An Updated Meta-analysis

Yi Sun, MD,* Fan Ye, MD,* Jing Wang, MMed,* Pan Ai, MMed,* Changwei Wei, MD,* Anshi Wu, MD,* and Wuxiang Xie, PhD†

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Anesth Analg 2020; 131: 712-9

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脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？

Table. Characteristics of Included Studies

Author and Year	Country	Study Design	Surgical Procedure	Age (y)	No. of Patients	Treatment Arms EEG-Guided	Treatment Arms Control	Postoperative Delirium Measurement	Follow-up Period
Jildenstål et al[13] 2012	Sweden	RCT	ENT surgery	40–94	32	16	16	CAM	Postoperative day 1
Chan et al[15] 2013	Hong Kong, China	RCT	Major noncardiac surgery	>60	921	462	459	CAM	Postoperative day 1
Radtke et al[14] 2013	Germany	RCT	Noncardiac surgery	>60	1277	638	639	*DSM IV*	Postoperative days 1–7
Whitlock et al[16] 2014	United States	RCT	Cardiothoracic surgery	>18	310	149	161	CAM-ICU	Twice daily until postoperative day 10 or ICU discharge, whichever occurred first
Wildes et al[8] 2019	United States	RCT	Major surgery	>60	1232	614	618	CAM and CAM-ICU	Postoperative days 1–5

Abbreviations: EEG, electroencephalography; ENT, ear, nose, and throat; CAM, Confusion Assessment Method; *DSM, Diagnostic and Statistical Manual of Mental Disorders*; CAM-ICU, Confusion Assessment Method for The Intensive Care Unit; RCT, randomized controlled trial.

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Anesth Analg 2020; 131: 712-9

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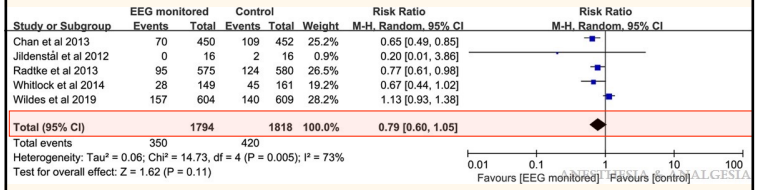
脳波モニターによる麻酔深度の適正化は術後せん妄を減らせるか？



脳波モニタが術後せん妄軽減に寄与するかどうかは

更なる検証が必要

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Anesth Analg 2020; 131: 712-9

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脳波モニタのWhy

術中覚醒→PTSDの回避

鎮静深度の適正化

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Whyから始める「脳波モニタ」

- 麻酔中の脳波モニタはなぜ重要か? – **Why?**
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脳波モニタの最近の話題 What?

レミマゾラム麻酔

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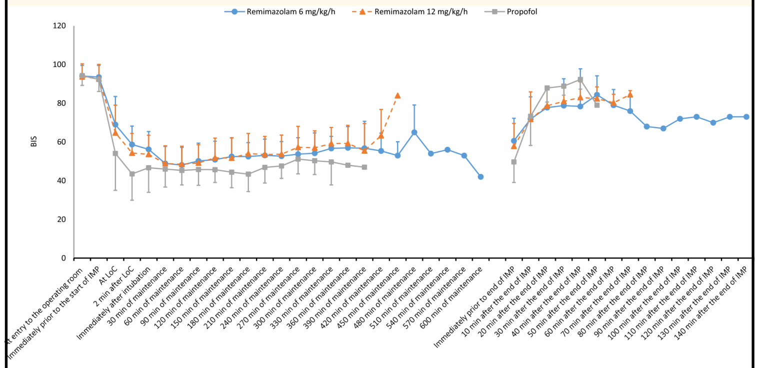
レミマゾラム麻酔ではBIS値が高い



		At entry to the operating room	Immediately prior to the start of IMP	At LoC	2 min after LoC	Immediately after intubation	30 min of maintenance	60 min of maintenance	90 min of maintenance	120 min of maintenance	150 min of maintenance	180 min of maintenance	210 min of maintenance	240 min of maintenance
6 mg/kg/h		137	135	134	135	138	137	131	121	105	78	57	47	32
12 mg/kg/h	N	130	129	132	133	134	134	129	114	97	80	62	47	36
Propofol		70	70	69	70	70	70	61	55	41	31	22	14	9

		270 min of maintenance	300 min of maintenance	330 min of maintenance	360 min of maintenance	390 min of maintenance	420 min of maintenance	450 min of maintenance	480 min of maintenance	510 min of maintenance	540 min of maintenance	570 min of maintenance	600 min of maintenance
6 mg/kg/h		28	22	15	9	6	5	2	2	1	1	1	1
12 mg/kg/h	N	24	11	4	3	3	2	1	0	0	0	0	0
Propofol		8	4	3	1	1	0	0	0	0	0	0	0

		Immediately prior to end of IMP	10 min after the end of IMP	20 min after the end of IMP	30 min after the end of IMP	40 min after the end of IMP	50 min after the end of IMP	60 min after the end of IMP	70 min after the end of IMP	80 min after the end of IMP	90 min after the end of IMP	100 min after the end of IMP	110 min after the end of IMP	120 min after the end of IMP	130 min after the end of IMP	140 min after the end of IMP
6 mg/kg/h		138	131	95	50	20	8	5	3	1	1	1	1	1	1	1
12 mg/kg/h	N	134	122	86	47	23	10	4	2	0	0	0	0	0	0	0
Propofol		70	58	26	5	2	1	0	0	0	0	0	0	0	0	0

Doi M, et al. *J Anesth* 2020; 34: 543-53

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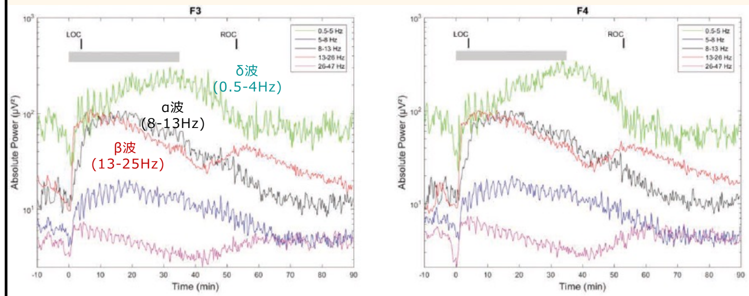
レミマゾラム麻酔における脳波の特徴



✓ α波とβ波（13-26Hz）が同程度のパワー → BIS or PSIの上昇に関与

プロポフォール・吸入麻酔薬（α波>>β波）

ベンゾジアゼピン系薬剤の特徴（**α波生成が弱い**）

Eisenried A, et al. Anesthesiology 2020; 132: 652-66

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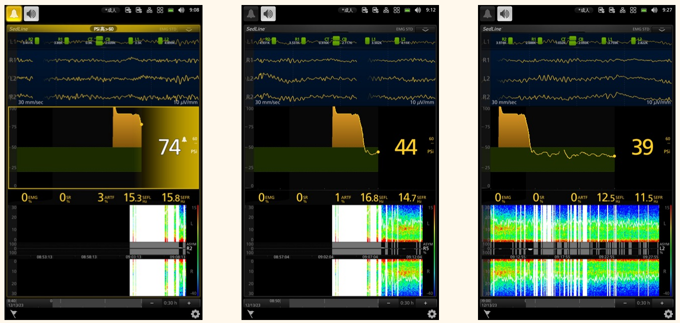
レミマゾラム麻酔：Spectral Edge Frequency (SEF) に注目

74歳男性, Remimazolam (5mg/kg/h-0.8mg/kg/h), Remifentanil (0.25μg/kg/min)

意識消失時　　意識消失から4分後　　意識消失から20分後



意識消失しているが
β波の影響でPSI, SEFは高い

α波（8-13Hz）のパワーも増加しているが
β波（13-25Hz）の影響でSEFが高い傾向

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レミマゾラム麻酔にはBIS値ではなくSEFが有用

Journal of Anesthesia (2022) 36:194–200
https://doi.org/10.1007/s00540-021-03030-7

ORIGINAL ARTICLE

Check for updates

Neurological sedative indicators during general anesthesia with remimazolam

Kazuhiro Shirozu[1] · Keiko Nobukuni[2] · Shota Tsumura[1] · Kazuya Imura[1] · Kosuke Nakashima[1] · Shinnosuke Takamori[1] · Midoriko Higashi[3] · Ken Yamaura[3]

✓ 全身麻酔患者30名のBIS®, Sedline®, 瞳孔径を同時測定し比較検討
✓ 平均BIS値>60は5名, 平均PSI>50は8名
✓ 瞳孔径は1.7 ± 0.2 mmで術中覚醒患者はいなかった.

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Shirozu K, et al. J Anesth 2022; 36: 194-200

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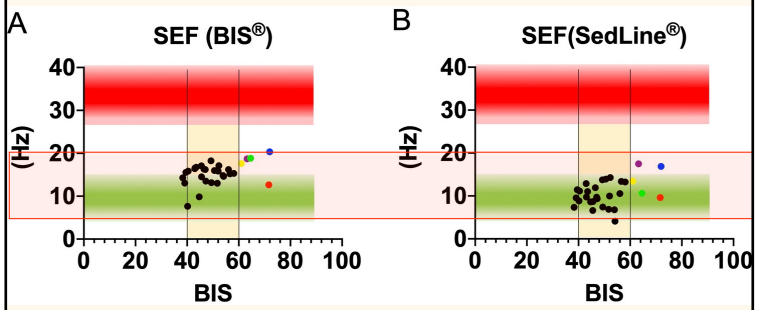
レミマゾラム麻酔にはBIS値ではなくSEFが有用



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Shirozu K, et al. J Anesth 2022; 36: 194-200

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Whyから始める「脳波モニタ」

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