2020

대한신경모니터링학회

KINMoS 술기 워크샵

2020년 7월 17일 (금) 14:00–17:50

온라인강의 / 백범김구기념관

KOREAN INTRAOPERATIVE NEURAL MONITORING SOCIETY

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대한신경모니터링학회 회원 여러분,

Covid-19으로 모두가 힘들게 지내는 시기입니다. 어려운 가운데에서도 우리 회원 여러분들 모두가 건강하게 잘 지내셨기를 바랍니다.
사실 올해는 해마다 진행하는 춘계 workshop을 춘계학술대회로 승격하여 주요 해외 연자도 초빙하는 등 학문의 장을 넓히려고 여러 가지 논의하였으나 아쉽게도 코로나 바이러스 창궐로 그 뜻을 이루지 못하였습니다.

그리고 현재까지 여전히 바이러스 감염으로부터 안전하지 못하긴 하지만 학문적, 인적 교류를 마냥 늦출 수만은 없어 7월 17일, 백범 김구 기념관에서 2020 KINMOS 술기 workshop을 개최하게 되었습니다.
이번 workshop은 방역 등을 고려하여 온라인과 오프라인을 병행하여 실시할 예정입니다.

이번 모임에서는 기존의 IONM의 기초지식, 최신지견 이외에도 경험이 많은 회원님들의 귀한 case discussion 그리고 후두 신경을 보존하는 과정에 대해 교과서에서 접하기 어려운 know how가 다루어질 것으로 기대합니다.
여러 가지 어려운 상황이긴 하지만 많은 참여로 그간의 학술 활동의 갈증을 해소할 수 있는 소중한 시간이 되기를 희망합니다.
늘 건강하시기 바랍니다.
감사합니다.

대한신경모니터링학회 회　장 **이강대**
이사장 **정웅윤** 배상

2020 KINMOS 술기 워크샵

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—— PROGRAM ——

14:00 – 14:05   Opening remark

14:05 – 15:15   **Session I. Case presentation or How I do it**
김정수, 정웅윤, 김훈엽, 이강대, 정광윤, 태경

15:15 – 15:30   *Coffee break*

Session II. Standard Procedure

15:30 – 15:45   Standarized IONM

15:45 – 16:00   Anesthesia for successful IONM

16:00 – 16:15   Troubleshooting algorithm

16:15 – 16:30   Normotive data and Interpretation of EMG signals

16:30 – 16:50   *Coffee break*

Session III. Advanced Procedure

16:50 – 17:05   Tip for nerve monitoring equipment: Medtronic vs Inomed

17:05 – 17:20   Monitoring of EBSLN during thyroid surgery

17:20 – 17:35   Transcutaneous/Transcartilage recording electrodes during
monitored thyroid surgery

17:35 – 17:50   Recent updates of IONM

17:50   Closing remark

Session I.

Case presentation or How I do it

좌장: 이재복 (고려대)
　　　 안순현 (서울대)

김정수
가톨릭대

학력
EDUCATION

| 1983 | M.D., College of Medicine, Catholic University |
| 1994 | Ph.D., College of Medicine, Catholic University |

경력
CAREER

1983 – 1984	Intern, Catholic University Hospital
1984 – 1988	Resident, Dept. of Surgery, St. Mary's Hospital. Catholic University
1988 – 1991	Military physician
1991 – 1992	Clinical Fellow, Daejeon St. Mary's Hospital
1995 – 1999	Assistant Professor, Uijeongbu St. Mary's Hospital
1997 – 1998	Visiting doctor , MD Anderson Cancer Center
2004 – 2019	Professor of Dept. of Surgery, Uijeongbu St. Mary's Hospital
2019 –	Professor of Dept. of Surgery, Seoul St.Mary's Hospital

정웅윤

연세대

학 력 EDUCATION		
1985 – 1991	Medical Degree, Yonsei University College of Medicine, Korea.	
2001	Master Degree, Graduate School of Yonsei University, Korea.	
2011	Degree of Ph. D. Graduate School of Korea University, Korea.	

경 력
CAREER

2009 – 2013	Executive director, the Korean Society of Head and Neck Oncology
2009 – 2011	Founding Member of Clinical Robotic Surgery Association (CRSA)
2010 – 2011	Chair of Endocrine organizing committee of Clinical Robotic Surgery Association (CRSA)
2011 – 2012	The president, the Society of Robotic Surgery (SRS)
2013 – 2015	The vice president, the Korean Association of Robotic Surgery
2014 – 2019	The vice president, the Korean Intraoperative Neural Monitoring Society
2014 – 2016	Editor in chief, the Korean Association of Endocrine Surgeons
2015 – 2017	The president, the Korean Association of Robotic Surgery
2017 – 2019	The founding president, the Asia-pacific association of Robotic Surgeons
2018 –	The vice president, the Korean Association of Endocrine Surgeons
2019 –	The chairman of the board of directors, the Korean Intraoperative Neural Monitoring Society

김 훈 엽

고려대

학 력
EDUCATION

1992 – 1998	서울대학교 의과대학 학사
2005 – 2010	서울대학교 의과대학 대학원 박사

경 력
CAREER

2002 – 2003	서울대학교병원 수련의
2003 – 2007	서울대학교병원 외과 전공의
2007 – 2008	서울대학교병원 갑상선내분비외과 전임의 및 임상강사
2008 – 2009	고려대학교안암병원 유방내분비외과 전임의
2009 – 2011	고려대학교안암병원 유방내분비외과 임상조교수
2011 – 2013	고려대학교 의과대학 외과학교실 및 고려대학교안암병원 유방내분비외과 조교수
2013 – 2018	고려대학교 의과대학 외과학교실 및 고려대학교안암병원 유방내분비외과 부교수
2015 – 2016	Research Professor and Faculty, Division of Head and Neck Surgery, Dept. of Otolaryngology – Head and Neck Surgery, Johns Hopkins University School of Medicine, USA
2016 –	고려대학교안암병원 유방내분비외과장
2018 –	고려대학교 의과대학 외과학교실 및 고려대학교안암병원 유방내분비외과 교수

이 강 대

고신대

학 력 EDUCATION	부산대학교 대학원 의학 박사
	부산대학교 대학원 의학 석사
	부산대학교 의학 학사

경 력 CAREER	2019 –	대한신경모니터링학회 회장
	2019 –	대한갑상선학회 회장
		제 12대 대한갑상선두경부외과학회 회장
		제1회 아시아태평양 갑상선외과학회(APTS) 학술대회장

정광윤

고려대

학 력
EDUCATION

고려대학교 대학원 의학 박사
고려대학교 대학원 의학 석사
고려대학교 의학 학사

경 력
CAREER

2016 – 2017	고려대학교 안암병원 건강증진센터 센터장
2013 – 2014	대한갑상선학회 부회장
2013 – 2015	대한갑상선두경부외과학회 회장
2014 –	대한신경모니터링학회 부회장
2016 –	대한암학회 이사
2018 –	대한 이비인후과학회 부이사장

태 경

한양대

학 력
EDUCATION

1985 -	한양대학교 의과대학 졸업

경 력
CAREER

Professor, Department of Otolaryngology–Head and Neck Surgery, Hanyang University, Seoul, Korea

Director, Hanyang University Hospital Cancer Center, Seoul, Korea

Secretary–General, Asia–Pacific Society of Thyroid Surgery (APTS)

Former President, Korean Society of Otorhinolaryngology–Head and Neck Surgery (2014–2015)

Session II.

Standard Procedure

좌장: 고윤우 (연세대)

강경호 (땡큐이비인후과)

송 라 영

중앙대

학 력 EDUCATION	2009	서울대학교 의과대학 졸업
	2016	서울대학교 의과대학 석사
	2018	서울대학교 의과대학 박사 수료

경 력 CAREER	2009 – 2014	서울대학교병원 수련의, 외과 전공의
	2014 – 2016	서울대학교병원 내분비외과 임상강사
	2016 – 2020	중앙대학교병원 외과 임상조교수
	2020 –	중앙대학교병원 외과 조교수

Standarized IONM

송 라 영 (중앙대)

▶ **Application of IONM**

- Identification (neural mapping) of the RLN
- Aid in dissection
- Prognostication of postoperative neural function
- Lesion site identification

REDUCE VOCAL CORD PALSY

▶ **International Neural Monitoring Study Group**

Electrophysiologic Recurrent Laryngeal Nerve Monitoring During Thyroid and Parathyroid Surgery: International Standards Guideline Statement

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▶ **KINMoS**

Review Article

Standards for Intraoperative Neuromonitoring in Thyroid Operations

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▶ **Standardization of IONM**

- Standards of equipment
- Standards in anesthesia
- Standards of equipment setup/endotracheal tube placement
- Standards in intraoperative loss of signal (LOS) evaluation
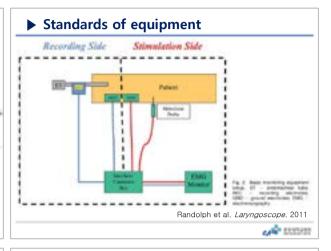- Standards in waveform definition and assessment

▶ Standards of equipment

- Current neural monitoring equipment
  - Audio-only systems vs. Audio + visual waveform

- Recording electrodes
  - Endotracheal tube electrode
  - Post-cricoid electrode
  - Trans-cartilage electrode
  - Trans-cutaneous electrode

- Stimulating electrodes
  - Monopolar
  - Bipolar
  - Stimulation dissector

Randolph et al. *Surgery of the Thyroid and Parathyroid Glands (3rd edition)*

▶ Standards of equipment

Randolph et al. *Laryngoscope.* 2011
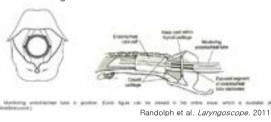
▶ Standards of equipment setup/ETT placement

- Monitoring tubes

Randolph et al. *Laryngoscope.* 2011

  ✓ Correct placement : when in contact with the medial surface of the bilateral cords

▶ Standards of equipment setup/ETT placement

- Common equipment-related problems
  - Malpositioning of ETT recording electrodes

  - Rotational error during intubation
  - Depth of insertion
  - Salivary pooling

▶ Standards of equipment setup/ETT placement
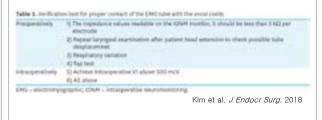
- General Equipment Setup

  ✓ Ground electrodes

  ✓ Monitor settings
    - 100mcV event threshold
    - Stimulation current 1~2mA
    - Impedance <5 kOhm

  ✓ Separate monitor and electrocautery units (>2m)

▶ Standards of equipment setup/ETT placement

- General Equipment Setup

Kim et al. *J Endocr Surg.* 2018
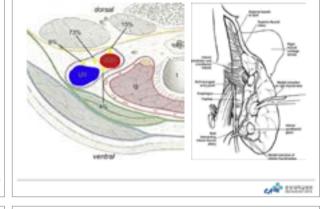
▶ Standardized IONM procedure

1. Preoperative laryngeal examination (L1)
2. Vagal stimulation before thyroid dissection (V1)
3. RLN stimulation at initial identification (R1)
4. RLN stimulation at the end of thyroid dissection and complete hemostasis (R2)
5. Stimulation of EBSLN at identification (S1)
6. Stimulation of EBSLN at final dissection (S2)
7. Vagal stimulation after complete thyroidectomy and hemostasis (V2)
8. Postoperative laryngeal examination (L2)

▶ Standardized IONM procedure

▶ Intraoperative RLN monitoring

Kim et al. *J Endocr Surg.* 2018

▶ Conclusion

- The routine use of IONM is suggested
  - difficult cases cannot always be predicted preoperatively

- EMG recording alone represents the "gold standard" of the nerve function assessment

- Standardized IONM can reduce vocal cord palsy rate

Thank you for your attention

Ra-Yeong Song
Chung-Ang University Hospital

채 민 석

가톨릭대 마취과
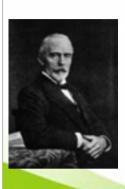
| **학 력**
EDUCATION | 2015~2019 | 가톨릭대학교 대학원 마취통증의학 박사 |
| | 2000~2007 | 원광대학교 의과대학 의학과 학사 |

경 력 CAREER	2020년~	가톨릭대학교 의과대학 서울성모병원 조교수
	2017~2020	가톨릭대학교 의과대학 서울성모병원 임상조교수
	2015~2017	가톨릭대학교 의과대학 서울성모병원 임상강사
	2011~2015	가톨릭대학교 의과대학 서울성모병원 레지던트
	2007~2008	가톨릭중앙의료원 인턴
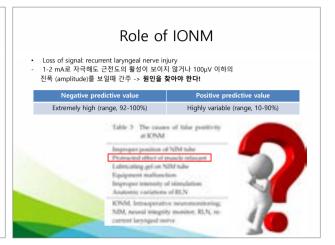
Anesthesia for successful IONM

채 민 석 (가톨릭대 마취과)

Dr. Kocher에 의해서 무균 수술법, 동맥 결찰 및 피막내 박리 요법이 갑상선 수술에 접목된 후 수술을 받는 환자의 사망률이 50% 이상에서 1% 미만으로 비약적인 호전을 보였다. 이 후 환자의 수술 후 삶의 질의 향상과 이전에는 관심을 받지 못 받았던 후두신경 (RLN) 마비와 같은 합병증의 관리가 중요한 이슈가 되었다. 2012년 한국 암 등록 통계에 의하면 수술 후 10년 생존율은 99%에 이를 정도로 아주 좋은 결과를 보인 반면, 입원한 환자들이 가장 걱정하는 것은 목소리의 변화 가능성 (46.6%) 이었다. 1960년대 수술 중 근신경모니터링 (IONM)이 소개된 후 RLN의 손상 합병증 빈도를 감소 시킬 수 있었지만, 아직 10% 정도의 손상에 의한 마비 발생률을 보이고 있으며, 양성질환의 0.2-2% 에서 암을 비롯한 재수술 에서는 20% 에 달하는 등 그 역할과 한계에 대해서 다양한 의견이 있어 왔다. IONM은 아주 높은 negative predictive value를 보이지만, positive predictive value 는 그 범주가 넓은 단점이 있다. 즉, IONM에서 정상일 경우 수술 후 신경손상 증상이 발생할 가능성은 극히 낮지만, 정상이 아닐 경우 신경손상 증상이 발생할 수도 그렇지 않을 수도 있어, EMG signal의 loss 시에 그 원인을 감별하는 것이 매우 중요하다. 여러 false positivity 원인 중 이번 시간에는 balanced anesthetic care의 아주 중요한 구성요소 중 하나인 근이완제와 IONM의 관련성에 대해서 알아보고자 한다.

Slide 1

- Dr. Kocher

- 갑상선 수술
① 무균 수술법
② 동맥 결찰
③ 피막내 박리

- Postoperative mortality ≥50% ➡ <1%

- 갑상선암 치료 후 10년 생존율 99%
  - 2012년 국가 암 등록 통계

- Quality of life ⬆ & complications ⬇

- 갑상선암 수술을 위해 입원한 환자들이 가장 걱정하는 것은? **목소리 변화 가능성 (46.6%)**

- Recurrent laryngeal nerve injury: 10%
① 양성 갑상선종: 0.2-2%
② 갑상선암, 그래이브스병, 갑상선 재수술: 20%

Slide 2

Role of IONM

- Loss of signal: recurrent laryngeal nerve injury
- 1-2 mA로 자극해도 근전도의 활성이 보이지 않거나 100μV 이하의 진폭 (amplitude)를 보일때 간주 -> **원인을 찾아야 한다!**

Negative predictive value	Positive predictive value
Extremely high (range, 92-100%)	Highly variable (range, 10-90%)

Table 3 The causes of false positivity at IONM

Improper position of NIM tube
Protracted effect of muscle relaxant
Lubricating gel on NIM tube
Equipment malfunction
Improper intensity of stimulation
Anatomic variations of RLN

IONM, Intraoperative neuromonitoring; NIM, neural integrity monitor; RLN, recurrent laryngeal nerve

Slide 3

The Laryngoscope
© 2011 The American Laryngological, Rhinological and Otological Society, Inc.

Electrophysiologic Recurrent Laryngeal Nerve Monitoring During Thyroid and Parathyroid Surgery: International Standards Guideline Statement

STANDARDS IN ANESTHESIA

Anesthesia Protocols for Neural Monitoring

An essential ingredient in successful RLN and vagal monitoring is partnership with the anesthesiologist. It is important to discuss monitoring with the anesthesiologist before the initiation of a neural monitoring program. It is best to discuss the need to have no muscle relaxation during the monitoring in advance so the anesthesiologist will have time to prepare before the first planned monitored case.

Slide 4
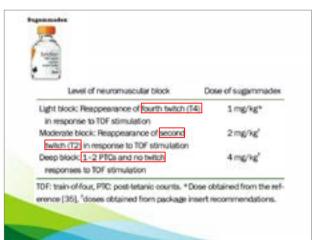
Neuromuscular blocking agents

TABLE 11-1 Depolarizing and nondepolarizing muscle relaxants.

Depolarizing	Nondepolarizing
Short acting Succinylcholine	Short acting Gantacurium[a] Intermediate acting Atracurium Cisatracurium Vecuronium Rocuronium Long-acting Pancuronium

[a]Not yet commercially available in the United States.

FIGURE 11-1 ...

Morgan & Mikhail's Clinical Anesthesiology, 5th edition.

Slide 5

Rocuronium
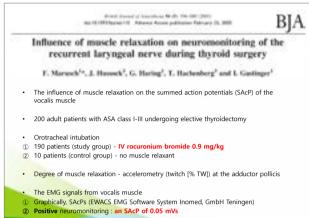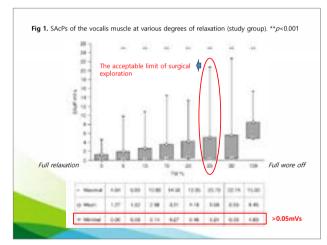
TABLE 11-6 A summary of the pharmacology of nondepolarizing muscle relaxants.

Slide 6

TABLE 11-7 Clinical characteristics of nondepolarizing muscle relaxants.

Sugammadex

Level of neuromuscular block	Dose of sugammadex
Light block: Reappearance of fourth twitch (T4) in response to TOF stimulation	1 mg/kg*
Moderate block: Reappearance of second twitch (T2) in response to TOF stimulation	2 mg/kg[ ]
Deep block: 1 - 2 PTCs and no twitch responses to TOF stimulation	4 mg/kg[ ]

TOF: train-of-four, PTC: post-tetanic counts. *Dose obtained from the reference [35]. [ ]doses obtained from package insert recommendations.

BJA

Influence of muscle relaxation on neuromonitoring of the recurrent laryngeal nerve during thyroid surgery

F. Marusch[1*], J. Hussock[2], G. Haring[2], T. Hachenberg[2] and I. Gastinger[1]

- The influence of muscle relaxation on the summed action potentials (SAcP) of the vocalis muscle
- 200 adult patients with ASA class I-III undergoing elective thyroidectomy
- Orotracheal intubation
① 190 patients (study group) - **IV rocuronium bromide 0.9 mg/kg**
② 10 patients (control group) - no muscle relaxant
- Degree of muscle relaxation - accelerometry (twitch [% TW]) at the adductor pollicis
- The EMG signals from vocalis muscle
① Graphically, SAcPs (EWACS EMG Software System Inomed, GmbH Teningen)
② **Positive** neuromonitoring : **an SAcP of 0.05 mVs**

Fig 1. SAcPs of the vocalis muscle at various degrees of relaxation (study group). **$p<0.001$

The acceptable limit of surgical exploration

Full relaxation   Full wore off

>0.05mVs

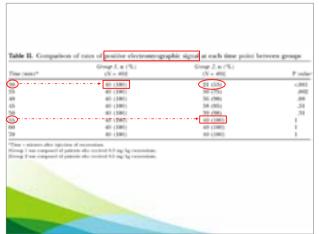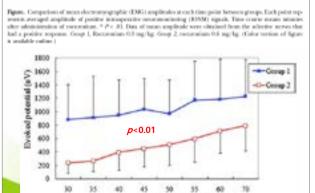## A comparative study between 1 and 2 effective doses of rocuronium for intraoperative neuromonitoring during thyroid surgery

I-Cheng Lu, MD[ ]; Cheng-Jing Tsai, MD[ ]; Che-Wei Wu, MD[ ]; Kuang-I Cheng, MD[ ]; Fu-Yuan Wang, MD[ ]; Kuang-Yi Tseng, MD[ ]; and Feng-Yu Chiang, MD[ ], Kaohsiung City, Taiwan

- **An ideal application of rocuronium** to enable **adequate muscle relaxation for intubation without significantly affecting the evoked potentials** measured by intraoperative neuromonitoring during thyroid surgery
- A total of 80 patients
① Group 1: **1 effective does (ED$_{95}$)** of rocuronium **(0.3 mg/kg)**
② Group 2: **2 ED$_{95}$** of rocuronium **(0.6 mg/kg)** for facilitate EMG endotracheal tube insertion
- Measurement of **evoked potentials** (accelerometry, % TW) **every 5 min** between the time period of **30 and 70 mins** after administration of rocuronium.
- A **positive** EMG signal: an activated evoked potential **≥100 μV**

Table II. Comparison of rates of positive electromyographic signal at each time point between groups.

Figure. Comparison of mean electromyographic (EMG) amplitudes at each time point between groups.

$p<0.01$
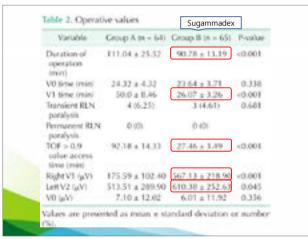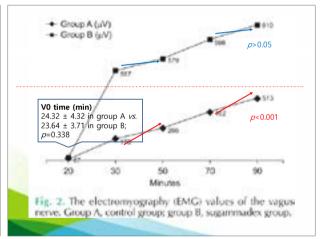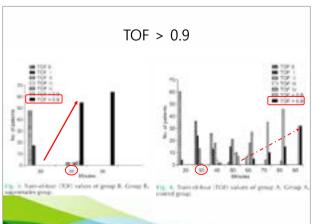
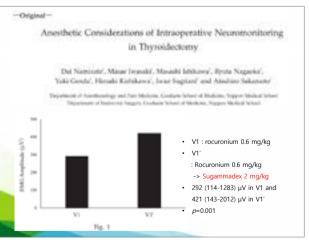| Group	1 ED$_{95}$ of rocuronium (n=40)	2 ED$_{95}$ of rocuronium (n=40)
Complete neuromuscular block	26 (65%)	40 (100%)
Time to intubation (maximal neuromuscular block)	208 ± 59 sec	114 ± 26 sec
Overall intubating conditions	*Excellent* in 15 patients *Good* in 21 patients *Poor* in 4 patients	*Excellent* in 37 patients *Good* in 3 patients

- Statistical significance (all, *p*<0.01)
- All patients experienced successful EMG endotracheal intubation on the first attempt.
- All vagus nerves were identified within 30 min of start of operation.

ASTR

ORIGINAL ARTICLE

Effect of intraoperative neuromonitoring on efficacy and safety using sugammadex in thyroid surgery: randomized clinical trial

- The efficacy and safety of sugammadex used to block the effect of NMBA during thyroid nerve monitoring surgery
- 129 patients were classified into
  ① The control group (group A) – **rocuronium 0.6 mg/kg**
  ② The sugammadex group (group B)
  – **rocuronium 0.6 mg/kg** -> (after the first vagal stimulation, V0) **sugammadex (2 mg/kg)**
- **Loss of signal:** an EMG signal below **100 μV** following stimulation of the vagus nerve; no laryngeal motion; and no visible laryngeal twitching following stimulation of the ipsilateral vagus nerve

Table 2. Operative values — Sugammadex

V0 time (min)
24.32 ± 4.32 in group A *vs.* 23.64 ± 3.71 in group B; *p*=0.338
p>0.05
p<0.001
Fig. 2. The electromyography (EMG) values of the vagus nerve. Group A, control group; group B, sugammadex group.

TOF > 0.9

Anesthetic Considerations of Intraoperative Neuromonitoring in Thyroidectomy

- V1 : rocuronium 0.6 mg/kg
- V1'
  : Rocuronium 0.6 mg/kg
  -> Sugammadex 2 mg/kg
- 292 (114-1283) μV in V1 and 421 (143-2012) μV in V1'
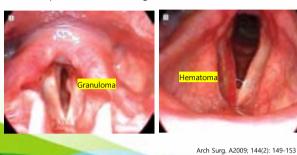- *p*=0.001

- **31.3% of vocal injury**
  - ✓ During intubation, surgical manipulation or extubation
  - ✓ Insufficient muscle relaxation
  - ✓ False positive neuromonitoring

Granuloma

Hematoma

Arch Surg. A2009; 144(2): 149-153

Take home messages

- Super low or high single dose of rocuronium should not recommend.
  - vocal cord injury
  - prolonged muscle relaxation
  - 0.3 – 0.6 mg/kg : applicable
- Repeat dose of rocuronium should not recommend.
- Sugammadex may be useful for IONM when residual block prolonged.
  - 2-4 mg/kg : applicable
- Anticipated difficulty for intubation
  - Video laryngoscopy may be useful.
- In obesity patients
  - Total body weight *vs.* ideal body weight *vs.* lean body weight

강상욱

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	2017 –	대한신경모니터링학회 (KINMoS) 국제협력이사
	2018 –	대한 갑상선내분비외과학회 영상 콘텐츠 홍보 위원장
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	2018 –	Asian-Pacific Association of Robotic Surgeons 총무이사
	2019 –	Society of Minimally Invasive Robotic and Endoscopic Thyroidectomy (MIRET) 학술 위원장

Troubleshooting algorithm

강상욱 (연세대)

이 형 신

고신대

학 력
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| 2004 – 2017 | 고신대학교 대학원 의학과, 석사/박사 |

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2003 – 2008	고신대학교 복음병원 이비인후과 인턴, 전공의
2007	일본 동경, 암연구소병원
2016	대만 가오슝, 가오슝대학병원

특 이 사 항
SPECIAL NOTE

2018 – 2021	한국연구재단, 이공학개인기초연구 (기본)
2018 – 2019	해양수산부 해양융복합 바이오닉스 소재 상용화 기술개발 (MIBC)
2015 – 2018	한국연구재단, 신진연구지원사업
2017 – 2018	부산대학교 대학산학연연구단지조성사업 (산학융합 공동 R&D)
2020 – 2022	중소벤처기업부 중소기업기술혁신개발사업 (시장확대형)

Normotive data and Interpretation of EMG signals

이 형 신 (고신대)

갑상선 수술 중 반회후두신경에 대한 효과적인 신경 모니터링 (Intraoperative neuromonitoring, IONM)을 위해서는 표준화된 절차 (V1-R1-R2-V2)를 따르고 이를 통해 나타나는 EMG 신호를 적절하게 해석하고 임상적 의미를 부여할 수 있어야 한다. 이를 위해서는 EMG 신호의 normative data를 이해하는 것이 필요한데, 정상적이고 표준적인 data를 알아야 병적인 상태를 진단할 수 있고 잘못된 정보를 걸러낼 수 있기 때문이다.

EMG 신호에서 가장 중요한 지표는 amplitude (uV)와 latency (msec)이다. Amplitude는 성대근육 내에 포함된 근섬유들의 합산된 EMG activity를 의미하며, latency는 신경 자극 후 유발된 waveform이 발생할 때까지의 시간에 해당한다.
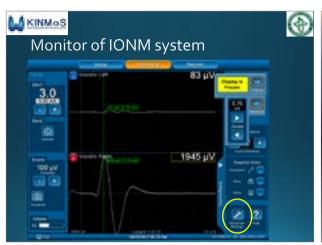
본 강의에서는 미주신경 (V1,V2)과 반회후두신경 (R1,R2) 자극시 나타나는 EMG 신호의 일반적인 양상을 살펴보고, 이를 기반으로 amplitude나 latency의 변화 등으로 나타나는 병적인 신호가 보일 때 이를 어떻게 해석하고 임상적으로 적용할 수 있는지 알아보고자 한다.
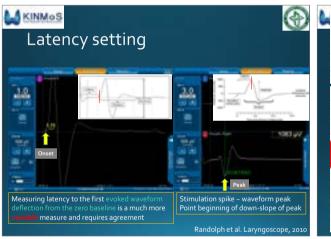
참고문헌

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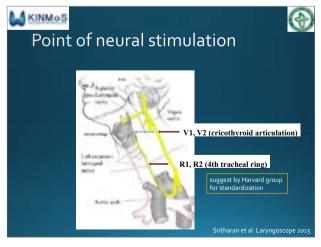
evaluation and outcome. Langenbecks Arch Surg 2017;402:691-9

2. Sritharan N, et al. The vagus nerve, recurrent laryngeal nerve, and external branch of the superior laryngeal nerve have unique latencies allowing for intraoperative documentation of intact neural function during thyroid surgery. Laryngoscope. 2015;125:E84-9

3. Randolph GW et al. Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international standards guideline statement Laryngoscope 2011;121 Suppl 1:S1-16

Monitor of IONM system

Latency setting

Onset

Peak

Measuring latency to the first evoked waveform deflection from the zero baseline is a much more variable measure and requires agreement

Stimulation spike – waveform peak Point beginning of down-slope of peak

Randolph et al. Laryngoscope, 2010

Point of neural stimulation

V1, V2 (cricothyroid articulation)

R1, R2 (4th tracheal ring)

suggest by Harvard group for standardization

Sritharan et al. Laryngoscope 2015

Increased amplitude after completing surgery

V1

V2

R1

R2

Lee et al. World J Surg, 2020

Lee et al. Laryngoscope, 2020

- Amplitude
  : reflects summated EMG activity
  from individual muscle fibers of the
  thyroarytenoid (peak to peak)
- Latency
  : no consensus
  : time from the stimulation spike to
  the first evoked waveform peak

Sritharan et al. Laryngoscope 2015

Latency	Amplitude
• Vagus > RLN	• Vagus < RLN
• Vagus : Lt > Rt	• EBSLN = 1/3 RLN

Sritharan et al. Laryngoscope 2015

Electrophysiology

- **Supra-maximal stimulation**
  - RLN and vagus nerve threshold : 0.3-0.4mA
  - Maximal response : 0.6-0.8 mA
  - Vagal stimulation / Mapping (suprathreshold stimulation, 2 mA)

Wu C. et al. Head Neck 2010

Level of stimulation current

- 0.8 ~ 1.0 mA
  - ✓ Primary setting

- 0.5 mA
  - ✓ Test extralaryngeal branches of RLN
  - ✓ Distinguish RLN from small vessel (prevent shunt stimulus)

- 2.0 mA
  - ✓ Localizing or mapping the path at the tracheoesophageal groove

Wu C. et al. Head Neck 2010

Loss of signal or weak signal?

LOS

- Type I (segmental) injury
  - Disrupted point or segment of nerve conduction
  - Clamping, traction, compression, thermal injury
  - R2p (-), R2d (+)

- Type II (global) injury
  - No disrupted point of nerve conduction on the whole exposed nerve
  - Positive response from contralateral vagus nerve
  - Over-stretching during medial retraction (possible cause)
  - Injury at distal intra-laryngeal focus

Wu et al. Gland Surg, 2015

R2p/R2d < 40% ☞ consider possibility of postoperative vocal cord paralysis

Wu et al. Langenbecks Arch Surg 2016

I-IONM as C-IONM

70/M, Rt. Nodular hyperplasia, Rt. lobectomy

Decreased amplitude after traction injury

Recovery of amplitude after 20 min / 30 min

Wu et al. Surgery, 2014

Session III.

Advanced Procedure

좌장: 김철호 (아주대), 남기현 (연세대)

지 용 배

한양대

학 력 EDUCATION	한양대학교 의학사 한양대학교 의학석사 한양대학교 의학박사

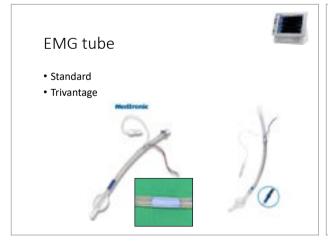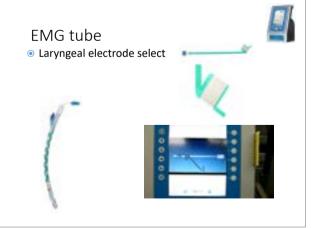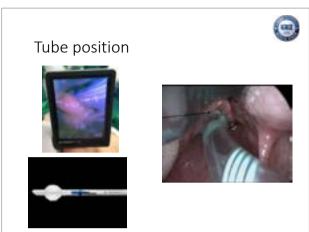| 경 력 CAREER		
	2009	한양대학병원 전임의
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	2011 – 2013	한양대학교 구리병원 임상조교수
	2014 – 2017	한양대학교 구리병원 조교수
	2017	미국 Johns Hopkins Hospital 방문교수
	2018 –	한양대학교 구리병원 부교수

Tip for nerve monitoring equipment: Medtronic vs Inomed
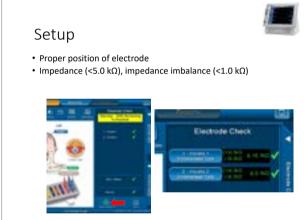
지 용 배 (한양대)

IONM equipment

IONM equipment

EMG tube

- Standard
- Trivantage

EMG tube

◉ Laryngeal electrode select

Tube position

Setup

Setup

Setup

- Proper position of electrode
- Impedance (<5.0 kΩ), impedance imbalance (<1.0 kΩ)

Setup

Setup

Channel select

Advanced setting

Advanced setting

• Audio setup

Advanced setting

• Audio setup

Advanced setting

• Audio set up

Advanced setting

• Audio setup – default

Advanced setting

• Monitoring

Measure

EMG display

• NIM-3
  • Customizable

• C2 NerveMonitor
  • Select the optimal channel
  • Artifact rejection algorithm

Snapshot

• Snapshot button

Snapshot

Snapshot

◉ USB keyboard
  • Print screen

Hotkey

Comment

Review & Report

Internal storage +

Review & Report

Report

Report

Report

Report

Review & Report

ASCII format -> editable

Selection of recordings   Print preview

Monitor accessory

Summary

⊙ NIM-3
  • Customizable setup

  • Display
    ○ Over threshold
  • Snapshot
  • Screen capture

  • Easy report

⊙ C2 NerveMonitor
  • Easy setup
  • Electrode
    ○ 4 channel
    ○ one size fit for all
  • Display
    ○ Channel select
  • Convenient
  • Internal storage & Review

  • Network connection

최 준 영

서울대

학 력 EDUCATION	1996 – 1998	서울대학교 자연과학대학 의예과
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Monitoring of EBSLN during thyroid surgery

최 준 영 (서울대)

Intra-operative nerve monitoring (IONM) during thyroid surgery has adopted widely as the gold standard of visualization of the recurrent laryngeal nerve (RLN). In contrast, most surgeons are not routinely expose or identify the external branch of the superior laryngeal nerve (EBSLN) during thyroidectomy. IONM has the potential to be utilized for identification of the EBSLN and functional assessment of its integrity; therefore, IONM might contribute to voice preservation following thyroidectomy or parathyroidectomy.

The superior laryngeal nerve (SLN) is a division of the vagal nerve (VN). The SLN include of two ramifications: the internal, which furnish sensory properties to the laryngeal lamina, and the external branch of the superior laryngeal nerve (EBSLN), which animate the CTM.

Surgical management of the EBSLN during thyroidectomy is complex and opposite to conventional dissection of the RLN, utmost clinicians tended to renounce, rather than consistently

denude, identify and monitor the EBSLN. There is an increasing consideration on the potential role of EBSLN estimation, monitoring, functional preservation and evaluation in thyroid and parathyroid surgery.

 EBSLN is surgically relevant as it is in anatomical proximity to the superior thyroid vessels (STV), inferior constrictor muscle, cricothyroid muscle (CTM) and thyroid cartilage.

 Optical recognition of the EBSLN is challenging, particularly in remedial surgery, apical lesions, or hemorrhage of the upper thyroid pole. Intraoperative neuromonitoring (IONM) has been proposed to coexist to vivid identification and to expedite localization and function preservation of the EBSLN while upper pole dissection and ligation.

 In a recent survey from the International Neuromonitoring Study Group (INMSG) reveal that intermitted IONM was applied in RLN handling by 95% of 120 respondents. IONM was adopted for identification of the EBSLN by 26.3% of less-experienced vs. 68.4% of experienced surgeons (P=0.004). Interestingly 90% of survey feedbacks affirm that EBSLN localization is undeniable in voice professionals.

 Furthermore, the "External branch of the superior laryngeal nerve monitoring during thyroid and parathyroid surgery: International

Neural Monitoring Study Group standards guideline statement" was published by the INMSG in 2013, with the aim to describe a standardized approach for EBSLN monitoring, improve the practice of EBSLN monitoring, optimize the clinical utility of IONM technique.

EBSLN damage produces changes in voice projection and quality, alongside alterations in the high-pitched sounds production ability, modified frequency of voice, altered voice timbre, declension in voice conduct, contracted voice virtue projection, added deed to communicate. EBSLN dysfunction related symptoms may, in some cases, deeply and negatively influence the standard quality of life. These symptoms may be, of note, more noticeable with professional speakers.

Enhance future research on EBSLN is essential to optimize its control during upper thyroid pole dissection and to close the interval and gap between IONM results for the RLN and EBSLN, pre- and postoperative assessment of vocal cord (VC) mobility and voice quality indexes.

At the end of the surgical procedure, intraoperative EBSLN monitoring can provide postoperative neural function prognostication: in particular, after the EBSLN stimulation (performed in the most cranial EBSLN segment, i.e., cranially to

the superior pole region surgically managed) a positive CTM twitch and EMG waveform are reliable evidence for functional EBSLN preservation.

RLN, EBSLN and VC structures and function are intimately related.

Infrequently, VC movement is defect-less, but voice ratio is slighted. For this reason, research towards neurophysiology and pathology of the EBSLN is up to date.

The complex neuroanatomy and physiology of VC and voice quality require a highly EBSLN knowledge, combined with an electrophysiological and clinical interpretation of the results before, during and after surgery.

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부산대

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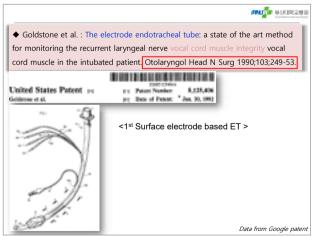
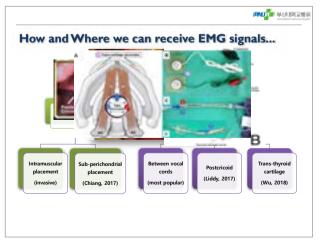| **경 력** CAREER		
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	(National Cancer Center Hospital, Tokyo, Japan) 단기연수
2020 –	부산대학교 의과대학 이비인후과학교실 기금조교수

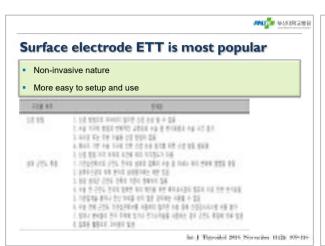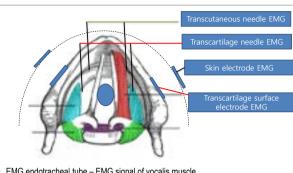# Transcutaneous/Transcartilage recording electrodes during monitored thyroid surgery

신 성 찬 (부산대)

Adhesive skin electrode in IONM

Transcutaneous Recording During Intraoperative Neuromonitoring in Thyroid Surgery

- Malposition of EMG tube – false positive results
  - To overcome the limitations of EMG tubes and needle electrode
  - At the upper borders of the left and right lamina of the thyroid cartilage

Adhesive skin electrode in IONM

Intraoperative Neuromonitoring of Recurrent Laryngeal Nerve During Thyroidectomy with Adhesive Skin Electrodes

- At both upper margins of thyroid cartilage

13

Adhesive skin electrode in IONM

Intraoperative Neuromonitoring of Recurrent Laryngeal Nerve During Thyroidectomy with Adhesive Skin Electrodes

- 39 NARs
- 4 NARs(10.3%) showed LOS during IONM with EMG tube, while all NAR showed acceptable biphasic signal from skin electrode.

Optimal location of skin electrode

- Investigate the optimal location of skin electrode to obtain maximal EMG signals of target muscle(LCA – main adductor)
- Compare an evoked amplitude obtained from skin electrode **medial** versus **lateral**

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Animal study

- 4 swine models – 8 NAR
- Upper/Middle/Lower – Medial/Lateral

❖ Investigate the location to obtain maximal EMG signal
❖ Compare the skin electrode with EMG tube

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Video clip

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Results – animal study

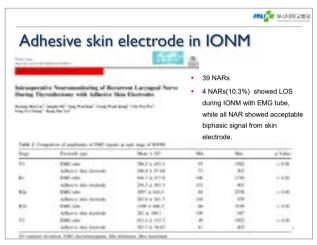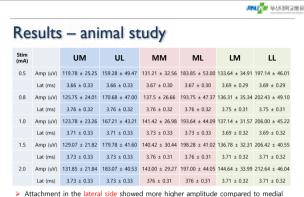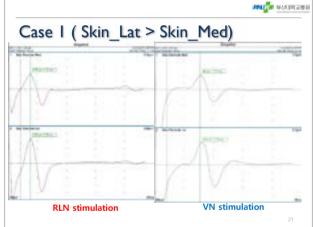| Stim (mA)		UM	UL	MM	ML	LM	LL
0.5	Amp (uV)	119.78 ± 25.25	159.28 ± 49.47	131.21 ± 32.56	183.85 ± 53.00	133.64 ± 34.91	197.14 ± 46.01
	Lat (ms)	3.66 ± 0.33	3.66 ± 0.33	3.67 ± 0.30	3.67 ± 0.30	3.69 ± 0.29	3.69 ± 0.29
0.8	Amp (uV)	125.75 ± 24.01	170.68 ± 47.00	137.5 ± 26.66	193.75 ± 47.37	136.31 ± 35.34	202.43 ± 49.10
	Lat (ms)	3.76 ± 0.32	3.76 ± 0.32	3.76 ± 0.32	3.76 ± 0.32	3.75 ± 0.31	3.75 ± 0.31
1.0	Amp (uV)	123.78 ± 23.26	167.21 ± 43.21	141.42 ± 26.98	193.64 ± 44.09	137.14 ± 31.57	206.00 ± 45.22
	Lat (ms)	3.71 ± 0.33	3.71 ± 0.33	3.73 ± 0.33	3.73 ± 0.33	3.69 ± 0.32	3.69 ± 0.32
1.5	Amp (uV)	129.07 ± 21.82	179.78 ± 41.60	140.42 ± 30.44	198.28 ± 41.02	136.78 ± 32.31	206.42 ± 40.55
	Lat (ms)	3.73 ± 0.33	3.73 ± 0.33	3.76 ± 0.31	3.76 ± 0.31	3.71 ± 0.32	3.71 ± 0.32
2.0	Amp (uV)	131.85 ± 21.84	183.07 ± 40.53	143.00 ± 29.27	197.00 ± 44.05	144.64 ± 33.99	212.64 ± 46.04
	Lat (ms)	3.73 ± 0.33	3.73 ± 0.33	376 ± 0.31	376 ± 0.31	3.71 ± 0.32	3.71 ± 0.32

➢ Attachment in the <u>lateral side</u> showed more higher amplitude compared to medial attachment
➢ Attachment in the <u>middle and lower level</u> of thyroid cartilage showed more higher amplitude compared to upper level.
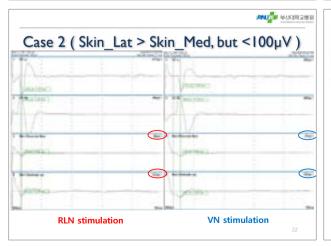
18

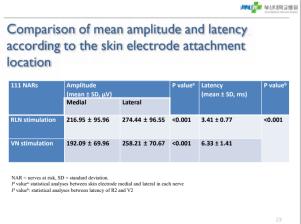## Optimal location of skin electrode in clinical setting

- September 2019 ~ June 2020
- Thyroidectomy in PNUH – hemi/total
- EMG tube was used, if indicated (N=16, 27 NAR)
- 78 patients
  - ✓ Lobectomy: total thyroidectomy = 41:37, 115 NAR(nerves at risk)
  - ✓ LOS – 4 NAR → Analysis of 111 NAR
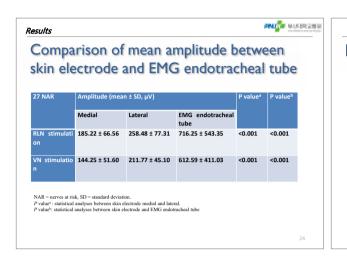- RLN and VN stimulation was performed at the end of the procedure.

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Clinicopathologic characteristics

Clinicopathologic characteristics	
Number of patients	78
Nerves at risk (NAR)	111
Type of surgery (Lobectomy/Total thyroidectomy)	41/37
Age (mean ± SD)	50.31 ± 12.66
Sex (M:F)	13:65
Body mass index (kg/m²)	24.53 ± 3.52
Tumor size (cm)	0.96 ± 0.77
Pathology	
Papillary thyroid carcinoma	70
Follicular thyroid carcinoma	3
Grave's disease	5

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Case 1 (Skin_Lat > Skin_Med)

RLN stimulation   **VN stimulation**

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Case 2 (Skin_Lat > Skin_Med, but <100μV)

RLN stimulation   **VN stimulation**

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Comparison of mean amplitude and latency according to the skin electrode attachment location

111 NARs	Amplitude (mean ± SD, μV)		P valueᵃ	Latency (mean ± SD, ms)	P valueᵇ
	Medial	Lateral			
RLN stimulation	216.95 ± 95.96	274.44 ± 96.55	<0.001	3.41 ± 0.77	<0.001
VN stimulation	192.09 ± 69.96	258.21 ± 70.67	<0.001	6.33 ± 1.41	

NAR = nerves at risk, SD = standard deviation.
P value[a] statistical analyses between skin electrode medial and lateral in each nerve
P value[b]: statistical analyses between latency of R2 and V2

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Results

Comparison of mean amplitude between skin electrode and EMG endotracheal tube

27 NAR	Amplitude (mean ± SD, μV)			P value[a]	P value[b]
	Medial	Lateral	EMG endotracheal tube		
RLN stimulation	185.22 ± 66.56	258.48 ± 77.31	716.25 ± 543.35	<0.001	<0.001
VN stimulation	144.25 ± 51.60	211.77 ± 45.10	612.59 ± 411.03	<0.001	<0.001

NAR = nerves at risk, SD = standard deviation.
P value[a]: statistical analyses between skin electrode medial and lateral.
P value[b]: statistical analyses between skin electrode and EMG endotracheal tube

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In summary,

- Although evoked amplitude is relatively low, IONM with adhesive skin electrode showed its feasibility and verification in both animal and human cases.
- We suggest that attachment location of skin electrode would be better in lateral side than medial side.

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Thank you for your kind attention

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이 준 협

가천대

학 력 EDUCATION	2005 – 2009	서울대학교 의학과 졸업, 학사
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Recent updates of IONM

이 준 협 (가천대)

In 2018, the International Neural Monitoring Study Group (INMSG) provided two state-of-the-art guidelines based on a detailed review of the recent monitoring literature at the time. The initial part I document reviewed electrophysiologic adverse EMG and LOS parameters with an algorithm for incorporation of this information in a planned bilateral surgery. The accompanying part II document represented complimentary set of guidelines that comprehensively reviews the management of the RLN, especially in the setting of invasive disease or laryngeal dysfunction, and incorporates surgical, glottic function, and IONM data. Through this presentation, I would like to introduce the recent updates published in PUBMED concerning IONM in thyroidectomy.

There were 74 articles published on IONM from 2018 to the present (July 2020). Twenty-five articles dealt on the general subject of IONM (such as institutional outcome reports, safety etc.), 10 on its application on minimally invasive thyroidectomy, 9 on the anatomical variations detected using IONM, 4 on the anesthesiologic aspects, 3 on the subject of external branch of superior laryngeal

nerve, 2 on staged thyroidectomy, 1 on completion thyroidectomy, and there were 5 metaanalysis or review articles. Furthermore, there were 4 articles on transcutaneous surface electrodes, 3 articles on transcartilagenous electrodes, laryngeal muscle electrode sensor, and surgical training aspect of the IONM each, and 2 on novel types of stimulator,

Today, I would like to introduce the technical advancements such as the sensors and stimulators

Preliminary 78

Surgical training

Is intraoperative nerve monitoring useful for surgical training in thyroid surgery?

Intraoperative Nerve Monitoring Is Useful for Surgical Training in Thyroid Surgery

IONM practice guidelines for the IONM supervising professional: some questions

Feasibility and efficacy of intraoperative neural monitoring in remote access robotic and endoscopic thyroidectomy

IONM and minimally invasive videoassisted thyroidectomy

Intraoperative neuromonitoring in traditional and miniinvasive thyroidectomy. A single center experience in 1652 nerve at risk.

Analysis of neuromonitoring signal loss during retroauricular versus

conventional thyroidectomy.

TO

Application of transoral continuous intraoperative neuromonitoring in natural orifice transluminal endoscopic surgery for thyroid disease: a preliminary study.

Feasibility of Continuous Intraoperative Neural Monitoring During Transoral Endoscopic Thyroidectomy Vestibular Approach in a Porcine Model

Monitored transoral endoscopic thyroidectomy via long monopolar stimulation probe

Recurrent laryngeal nerve management in transoral endoscopic thyroidectomy

Stimulating and dissecting instrument for transoral endoscopic thyroidectomy: proof of concept investigation

BABA

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Intraoperative Neural Monitoring in Endoscopic Thyroidectomy Via Bilateral Areola Approach

Detachable stimulator

Development of a Novel Detachable Magnetic Nerve Stimulator for

Intraoperative Neuromonitoring.

Development of an Attachable Endoscopic Nerve Stimulator for Intraoperative Neuromonitoring during Endoscopic or Robotic Thyroidectomy.

Development of a Novel Intraoperative Neuromonitoring System Using a Surface Pressure Sensor to Detect Muscle Movement: A Rabbit Model Study.

Continuous Neural Monitoring in Endoscopic Thyroidectomy: Feasibility Experimental Study for Transcutaneous Vagal Nerve Stimulation.

Transcutaneous Recording During Intraoperative Neuromonitoring in Thyroid Surgery

Feasibility of Intraoperative Neuromonitoring During Thyroid Surgery Using Transcartilage Surface Recording Electrodes.

Intraoperative Neuromonitoring of Recurrent Laryngeal Nerve During Thyroidectomy with Adhesive Skin Electrodes.

Development of a Novel Intraoperative Neuromonitoring System Using an Accelerometer Sensor in Thyroid Surgery: A Porcine Model Study

Modified arytenoid muscle electrode recording method for neuromonitoring during thyroidectomy.

Intraoperative Neuromonitoring Using a Single Transcartilage Needle Electrode During Thyroidectomy

Efficacy of Transcartilaginous Electrodes for Intraoperative Neural

Monitoring During Thyroid Surgery.

Tube based continuous monitor

Noninvasive, tube-based, continuous vagal nerve monitoring using the laryngeal adductor reflex: Feasibility study of 134 nerves at risk.

General

Mini-invasive thyroidectomy and Intraoperative Neuromonitoring (IONM): a single high-volume center experience in 215 consecutive cases.Effect of intraoperative nerve monitoring on postoperative vocal cord palsy rates after thyroidectomy: European multicentre registry-based study.Intraoperative Neuromonitoring in Thyroid and Parathyroid Surgery

Utility of continuous intraoperative neural monitoring in thyroid surgery in a low volume centre.

Intraoperative nerve monitoring is used routinely by a significant majority of head and neck surgeons in thyroid surgery and impacts on extent of surgery-Survey of the American Head and Neck Society.

Neural monitoring in thyroid surgery is here to stay.

Intraoperative Neuromonitoring in Thyroid Surgery: An Efficient Tool to Avoid Bilateral Vocal Cord Palsy.

Early detection of recurrent laryngeal nerve damage using intraoperative nerve monitoring during thyroidectomy.

Recommendations on the use of neuromonitoring in thyroid and

parathyroid surgery.

Effect of nerve monitoring on complications of thyroid surgery.

[Intraoperative neuromonitoring in endocrine surgery: when is it appropriate?].

Routine Intraoperative Neuromonitoring of the Recurrent Laryngeal Nerve to Facilitate Complete Resection and Ensure Safety in Thyroid Cancer Surgery

New Paradigms for Neural Monitoring in Thyroid Surgery

Intraoperative neuromonitoring versus visual nerve identification for prevention of recurrent laryngeal nerve injury in adults undergoing thyroid surgery

Intra-Operative Neural Monitoring of Thyroid Surgery in a Porcine Model.

Intraoperative nerve monitoring in endocrine surgery: prevalence and reasons for its use in Australia and New Zealand

Continuous versus intermittent intraoperative neuromonitoring in complex benign thyroid surgery: A retrospective analysis and prospective follow-up.

IONM and thyroidectomy in benign thyroid disease. Analysis of adverse events.

Increased prevalence of neural monitoring during thyroidectomy: Global surgical survey.

Application of Continuous and Intermittent Intraoperative Nerve Monitoring in Thyroid Surgery.

Intraoperative nerve monitoring in thyroid surgery-shifting current paradigms

[Continuous intraoperative neuromonitoring (cIONM) in head and neck surgery-a review. German version].

Laryngeal nerve morbidity in 1.273 central node dissections for thyroid cancer

Twenty-year experience of paediatric thyroid surgery using intraoperative nerve monitoring

Recurrent laryngeal nerve paralysis after thyroid cancer surgery and intraoperative nerve monitoring.

Association Between Recurrent Laryngeal Nerve Calibre and Body Figure: A Preoperative Tool to Assess Thin-Diameter Nerves in Thyroidectomy.

Safety of high-current stimulation for intermittent intraoperative neural monitoring in thyroid surgery: A porcine model.

Anesthesia

Anesthetic Considerations of Intraoperative Neuromonitoring in Thyroidectomy

Effect of intraoperative neuromonitoring on efficacy and safety using sugammadex in thyroid surgery: randomized clinical trial.

Influence of Sevoflurane-Based Anesthesia versus Total Intravenous Anesthesia on Intraoperative Neuromonitoring during Thyroidectomy.

THYROID SURGERY, IONM AND SUGAMMADEX SODIUM RELATIONSHIPS: BENEFITS IN SUGAMMADEX SODIUM USE FOR IONM

EBSLN

Intraoperative Monitoring of External Branch of the Superior Laryngeal Nerve: Functional Identification, Motor Integrity, and its Role on Vocal Cord Function.

Identification of the External Branch of the Superior Laryngeal Nerve during Thyroid Surgery.

Visual and electrophysiological identification of the external branch of superior laryngeal nerve in redo thyroid surgery compared with primary thyroid surgery.

RLN variations

Modification of the Surgical Strategy for the Dissection of the Recurrent Laryngeal Nerve Using Continuous Intraoperative Nerve Monitoring.

A functional assessment of anatomical variants of the recurrent laryngeal nerve during thyroidectomies using neuromonitoring.

Bilateral patterns and motor function of the extralaryngeal branching of the recurrent laryngeal nerve.

Motor Interconnections Between Superior and Inferior Laryngeal Nerves

[Study progress of intraoperative neuro-monitoring of recurrent laryngeal nerve in thyroidectomy]

Nonrecurrent Laryngeal Nerve: Precise Detection by Electrophysiological Nerve Monitoring

Impact of the anatomy of laryngeal nerves on intraoperative neuromonitoring results in surgery of thyroid gland and functional results after partial laryngectomies

Utility of intraoperative neuromonitoring in detecting recurrent nerve's anatomical anomalies during thyroidectomy

Nonrecurrent Laryngeal Nerve: Precise Detection by Electrophysiological Nerve Monitoring

Review, Metaanalysis

Protective Effects of Intraoperative Nerve Monitoring (IONM) for Recurrent Laryngeal Nerve Injury in Thyroidectomy: Meta-analysis.

Importance of incorporating intraoperative neuromonitoring of the external branch of the superior laryngeal nerve in thyroidectomy: A review and meta-analysis study

A Review of Methods for the Preservation of Laryngeal Nerves During Thyroidectomy

Methodological Quality of Systematic Reviews of Intraoperative Neuromonitoring in Thyroidectomy: A Systematic Review

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Continuous intraoperative neuromonitoring (cIONM) in head and

neck surgery-a review

Completion

Complication Risk in Secondary Thyroid Surgery.

Staged thyroidectomy

Intraoperative intermittent neuromonitoring of inferior laryngeal nerve and staged thyroidectomy: our experience

Staged Thyroidectomy: A Single Institution Perspective

2020
KINMoS 술기 워크샵

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