SCOT (Smart Cyber Operating Theater) project: Advanced Medical Information Analyzer for Guidance of the Surgical Procedures

Institute of Advanced Biomedical Engineering & Science, Tokyo Women’s Medical University

A present situation in medical practice

The nuances of the clinical practice are usually recorded by the medical staff themselves. The same individuals also control the information considering the patient, who is the object of their activities.

Problems for reliable and objective evaluation of the collected data by the independent observers.

- In identification of the violation of the normal intraoperative course, whether it is caused by human errors, organizational flaws, or technical malfunction.

- In identification of the cause of the complications, which lead to inability of their avoidance in further clinical practice.
Concept of SCOT (Smart Cyber Operating Theater)

Medical practice management support system

Medical staff

Information on medical practice

Vital signs

Patient

Vital sign

Medical practice support information

Medical practice
Effects of SCOT (Smart Cyber Operating Theater) Development

- Providing of high-level safety
- Optimization and standardization
- Correction of the technological gaps (Elimination of medical-care disparities)
- Objective informed consent
- Providing of the progress
SCOT Function (Operating Theater System 1/11)

**Indoor image recording system**

- The collection of the operating theater view using the circumference-type camcorder.
- Image processing (The distortion correction of the panorama image, etc..)
- 18 CCD camera

Circumference picture recording → Indoor image → Video signal processing → Image processing → Image compression → Indoor image → Surgical information analysis system
Compressibility of image & surgical process

- General anesthesia
- Vital monitor
- Skin closure
- Layout change
- Tumor removal
- Carrying out
- Awake state

- craniotomy
- Dura opening
- MRI
Indoor sound recording system

- Collection of the generated sounds using directional microphone array in the operating theater.
- Purposeful sounds (non-voice) are extracted (the kind of a sound in the collected sounds is specified, and its source is located.)

SCOT Function (Operating Theater System 3/11)

Indoor sound recording → Sound signal processing → Source location → Purpose Sound extraction → Non-voice → Surgical information analysis system
Surgical field sound recording system

- Collection of sounds around the surgical field with sensitive microphone
- Sound samples are specifying and extracted according to their kind and purpose
Analysis of the Audio Information

- Non-verbal method
  - A word has many meanings within various contexts
  - Difficulty in recognition of the verbal information
    - Unclear speech because of the surgical mask
    - Background music
Development of the intraoperative flow cytometry for rapid determination of glioma presence and its histopathological grade

Determination of the DNA content requires just 7-8 min.
Difficulties of Intraoperative Histopathological Diagnosis

• Diagnosis on frozen sections
  – Requirements for speed & accuracy
  – Effects of artifacts due to tissue processing

• Central histopathological evaluation in randomized studies reveals 16% of diagnostic errors in each individual facility

• Rapid analysis of the resected tissue is required for:
  – Discrimination of the neoplastic and normal tissue
  – Determination of tumor malignancy

• Possible improvement by combined use of several intraoperative histopathological techniques
Current Diagnostic Method

Tissue extraction

Resected tissue

Diagnostic result

Diagnosis by specialist
Automatic judgements on tissue grade-of-malignancy based on the evaluation of the DNA content

Determination of tumor presence

Extracted tissue rapid analysis system

- Flow cytometer application

Judgment in 8 minutes
Dynamic monitoring system

- It sets the parameter of each medical electronic equipment by entry of the medical staff.
- Vital signs of the patient are collected from each medical electronic device and simultaneously displayed in integrated fashion.

SCOT Function (Operating Theater System 6/11)

Patient dynamic phase
Information recording

Wireless LAN connection

ME instrument setting content

ME instrument setting

Signal processing

ME instrument control information input

Vital sign

Vital sign

Vital sign

Surgical information analysis system

Patient monitoring

Bed log

SEP, MEP etc.
Awake surgery

IEMAS 2
Methodology of awake surgery

language > motor, laryngeal mask (LMA), persistent alertness during surgery

Flow of awake surgery & anesthesia

T.W.M.U. experience

- Propofol (unit: µg/mL)
  - 3 ~ 4
  - 2 ~ 2.5
  - 2 ~ 3

- Fentanyl

- Local anesthesia

- Antiemetic drug

- Beginning of Surgery
- Craniotomy
- Awake surgery
- Monitoring
- LMA intubation
- LMA removal
- Nasal canula for intubation
- Extubation
- Entry
- Airway management
- Anesthesia induction
- Exit
- T.W.M.U. experience
Sharing information to prevent false positive responses

- Functional information
  - Awake surgery & Task
- Anatomical information
  - Intraoperative MRI & Navigation
- BIS monitor
  - Awake level

- Functional information
  - Mapping of speech area
• Ultrasonic emission tag - microphone array
  – 4D information (3D position + time)

Recording of the Staff Position and Motion

(Prof. Izumi, AIST, JAPAN)
Motion of surgical staff
SCOT Function (Operating Theater System 10/11)

**Operating theater information-display-system**

- It displays information collected and generated by the operating theater system and the strategy desk system.
- The content of displayed information is chosen automatically according to the needs of surgical situation.
Medical staff within and outside of the operating theater sharing all intraoperative information
The monitor display-screen non-contact control system

Xbox 360 Kinect sensor
Non-Touch Controllable Intuitive Interface

Tokyo Women’s Medical University
Faculty of Advanced Techno-Surgery: FATS
Advanced brain : strategy desk

Integration of the surgical information and support of the surgical decision-making
Use of the strategy desk

The future can be visualized at present using the experience of the past !!!

「Action」=「Knowledge(Science・Evidence・DB)」+「Decision-making」

(If decision-making is based on knowledge the risk of action can be eliminated)

probabilistic safety assessment: PSA

VS.

「judgement」=「fact」+「prediction (experience)」

Fools say they learn from experience; I prefer to learn from the experience of others.

Bismarck
Strategy desk

Initial treatment planning influences the outcome. Probability-based treatment planning is necessary for prediction of the possible outcome and choice of the most optimal treatment option (requirement for comprehensive database). Precision of prediction improves with the accumulation of the clinical data.
Prediction of the possible reaction on the action

It estimates the reaction on the action, which is strongly expected based on the actual treatment dynamic state of the patient and information from database, and evaluates the possible risk as well as positive consequences of the action based on the probability model.
Simulation of the whole treatment process, prediction of the outcome, and evidence-based choice of the optimal treatment strategy

Construction of the digital biomodel of the disease
Characteristics of terra hertz (THz)

- **Frequency:** several hundreds of GHz
- **Working frequency of medical equipment, including MRI scan:** completely different
- **The wave length is short:**
  - Antenna gain is high even if it makes equipment small.
  - Possibility to communicate with high quality in the several mW low output (indoor communication on the short distance).
- **Good control of the direction of the transmission beam:** possible to use multiple channels
- **Radio in the operating room:** Radio I/F with very good affinity
Ultra high-definition image (4K video) Incompressibility transmission

Tokyo (KDDI)

10 Gps THz wireless LAN

Kyoto (left)  Tokyo (right)

JGN2plus line (10GbpsEthernet)

10 Gbps Fixed-line

Kyoto (NICT institute)

10Gbps Fixed-line

Tokyo (NICT head office)

2011.2.4. (Friday)

c.a. 520km
Patient dynamic phase monitoring & operational status monitoring of medical equipment system (THz)

- Awake surgery information such as IEMAS are collected.
- Vital signs of the patient are collected from each ME equipment.

Ultra high-definition image (4K video) Incompressibility transmission
SCOT Function (Strategy Disc System 2/4)

Surgical information management system

- Verification of the surgical plan, analysis of medical staff work flow, and display of probability-based results.
- Verification of the surgical record, prediction of surgical results and quantitative evaluation of the medical practice.
SCOT Function (Strategy Disc System 3/4)

Strategy desk information display system

- Collection of the information generated by operating theater system and strategy desk system.
- Display of the information: automatic selection of the content according to the surgical requirements.
Remote maintenance & monitoring of imaging device/monitoring device/sound
Integration of multi-modal images & medical information
Strategy desk

Remote maintenance & monitoring of imaging device/monitoring device/sound
Integration of multi-modal images & medical information

MRI console

- Patient
- BIS
- Navigation

Local workspace (preoperative images etc.)

Theater image
The medical information necessary for present state and decision of each stage briefly and intuitively displays it.

Operating procedure:
- Anesthesiologist
- Surgeon
- Scrub nurse
- Operating nurse
- I-MRI・Navigation
- IEMAS
- SEP・MEP
- Pathology・flow cytometry

Necessary resource:
DM navi
fluctuation

- job finished benchmark
- difference from allowed time
- divergence from goal
- risk assessment

optimization of difference
roadmap
goal
actual performance
stage
• Safety supporting technology in medical process

- Keeping safety of inspection and medical care
- Providing safety in therapy
- Evaluation of techniques based on previous experience
- Prediction of the intraoperative events
Technical problems

- What should be recorded?
- Reliable and easy recording of information.

  Monitoring of the surgical process without interference with
  the work of the staff and use of the equipment.

  Avoidance of failures during recording of the information.

  Avoidance of the increased electric power consumption and noise related to
  recording of the information in the operating theater.

- Easy registration and automatic analysis of the records.
- Requirement for analyzing of many different records within a
  limited time frame.

  Registration of the records within the limited time.

  Extraction of the important information from the records.
Advanced Medicine based on grand sum of nano-tech, bio-tech, high-tech and so on.

Future medicine

Chemical IC

Nano-bio interface

Nano-machine therapy

Regenerative medicine

DDS

Tip technology

Gene therapy

High-tech medicine (robotics, artificial organ)
Tokyo Women’s – Waseda Joint Institution for Advanced Biomedical Sciences: TWIns

Gross floor area: 20,000m²
Waseda U. floor area: 11,000m²  TWMU floor area: 6,500m²

Common floor area for another EBM: 2,500m²
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Thank you very much for your kind attention!

Kiitos!!

You are always welcome in our Institute!