JAPANESE-FINNISH JOINT SYMPOJIUM
13-15 December 2011 Helsinki, Finland

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

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A present situation in medical practice

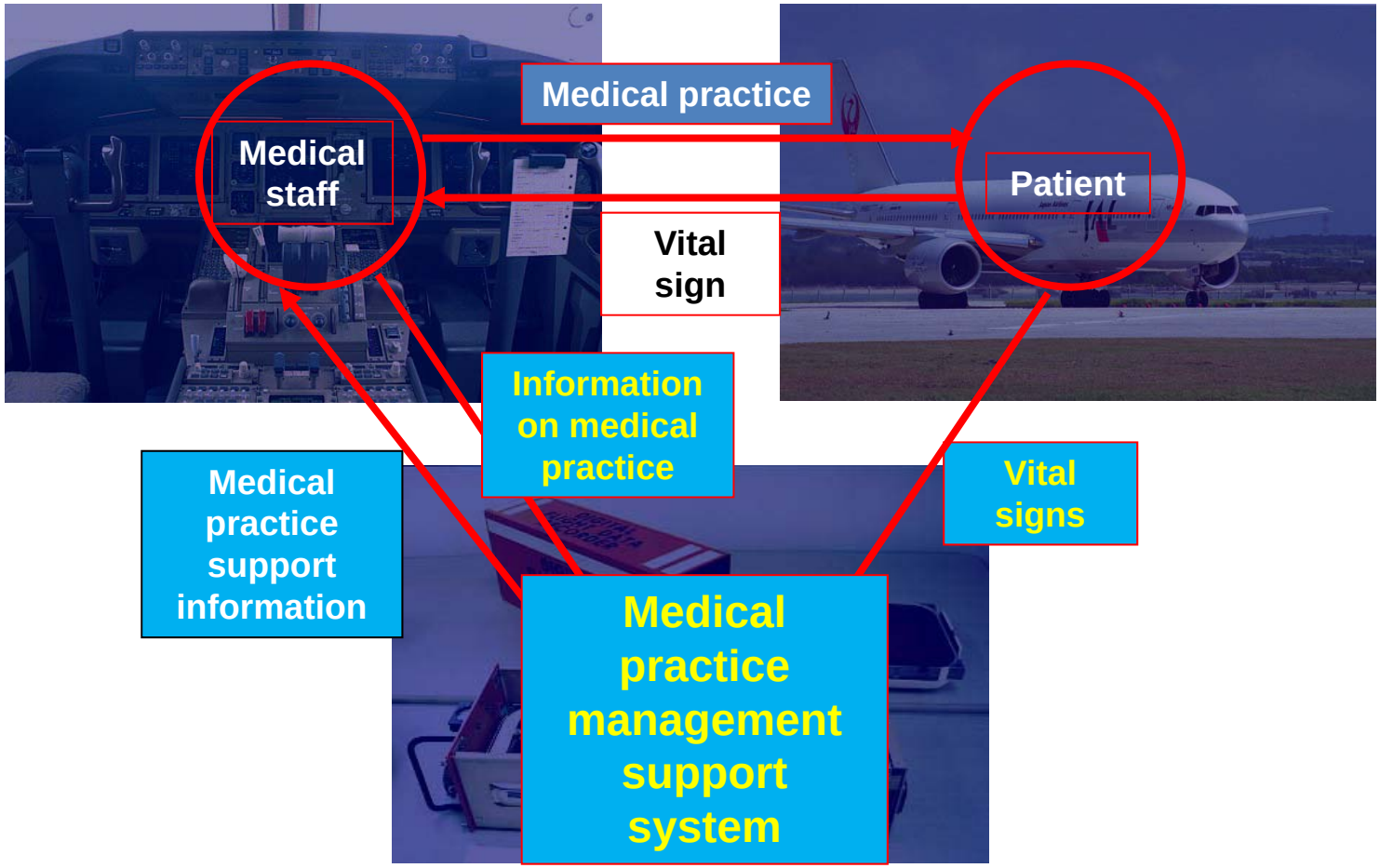
The nuances of the clinical practice are usually recorded by the medical staff themselves. The same individuals also control the information considering the patient, who is the object of their activities.

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)



Concept of medical practice management support system

Effects of SCOT (Smart Cyber Operating Theater) Development

- Providing of high-level safety
- Optimization and standardization
- Correction of the technological gaps

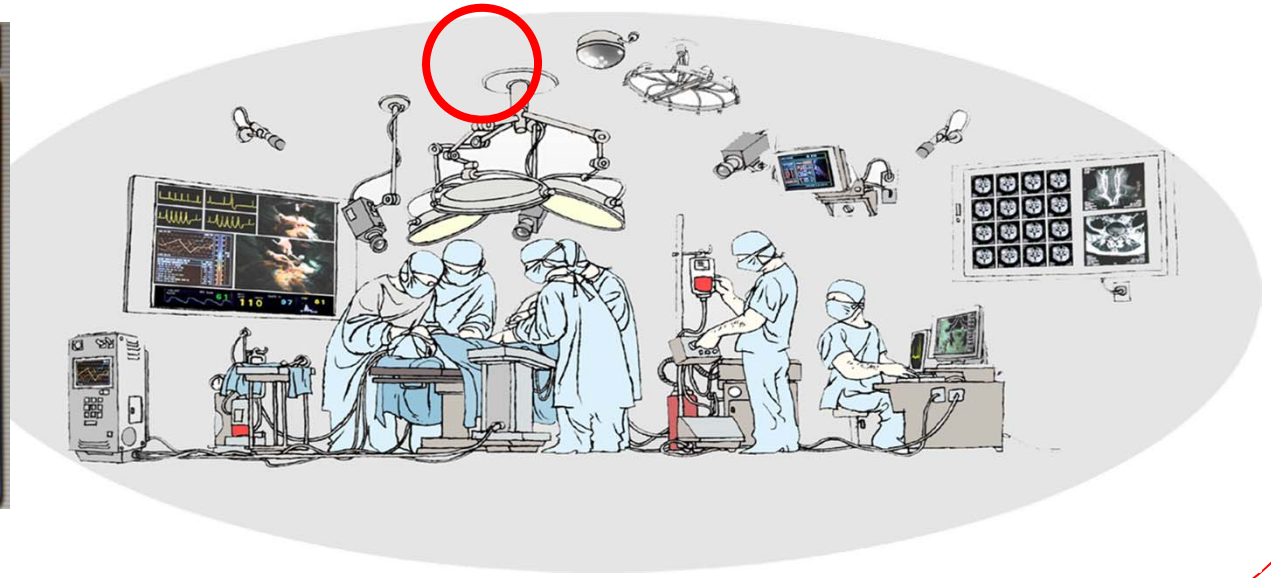
  (Elimination of medical-care disparities)
- Objective informed consent
- Providing of the progress

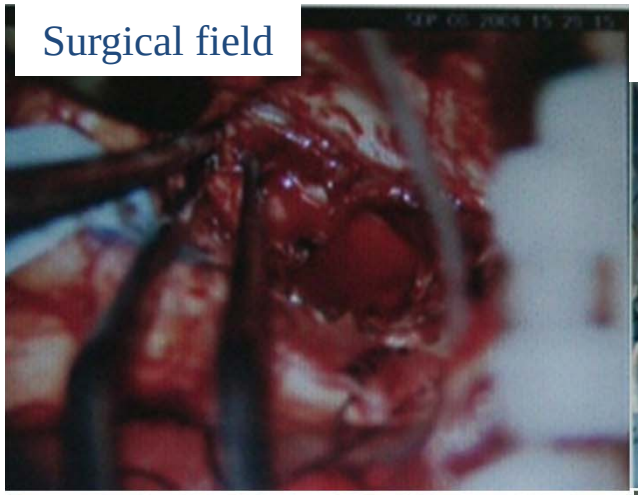
SCOT Function（Operating Theater System 1/11）

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



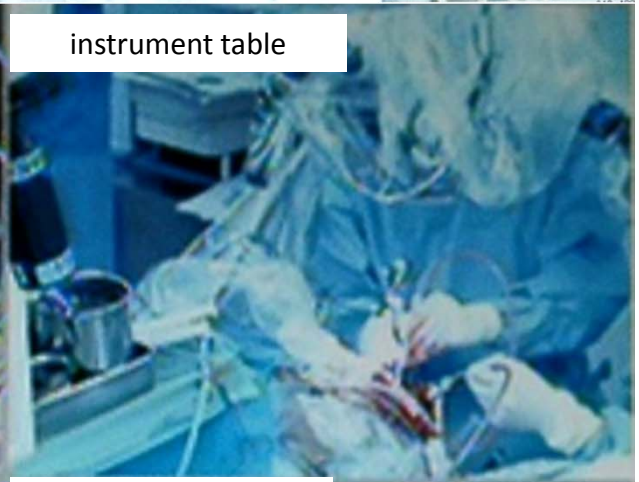

Surgical field

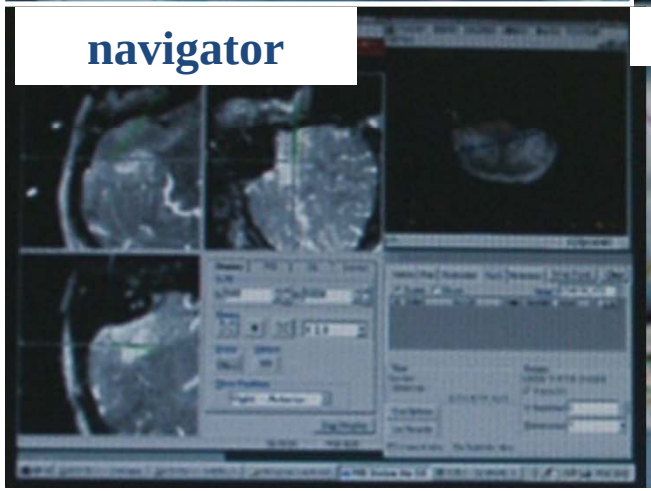

ceiling

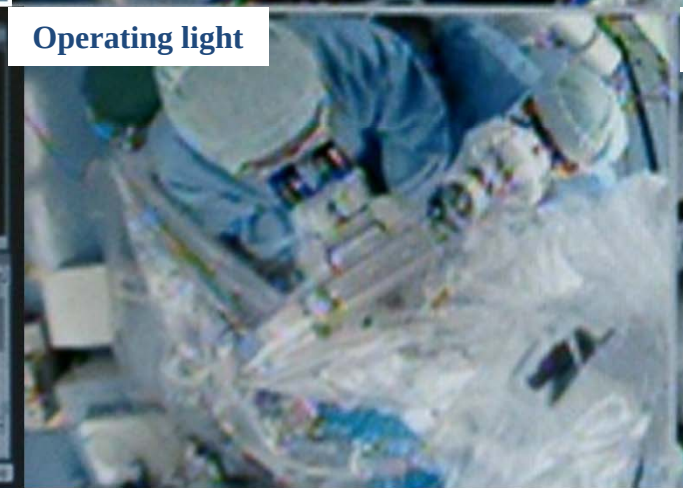

Anesthesia monitor


Surroundings of the microscope


anesthesiologist

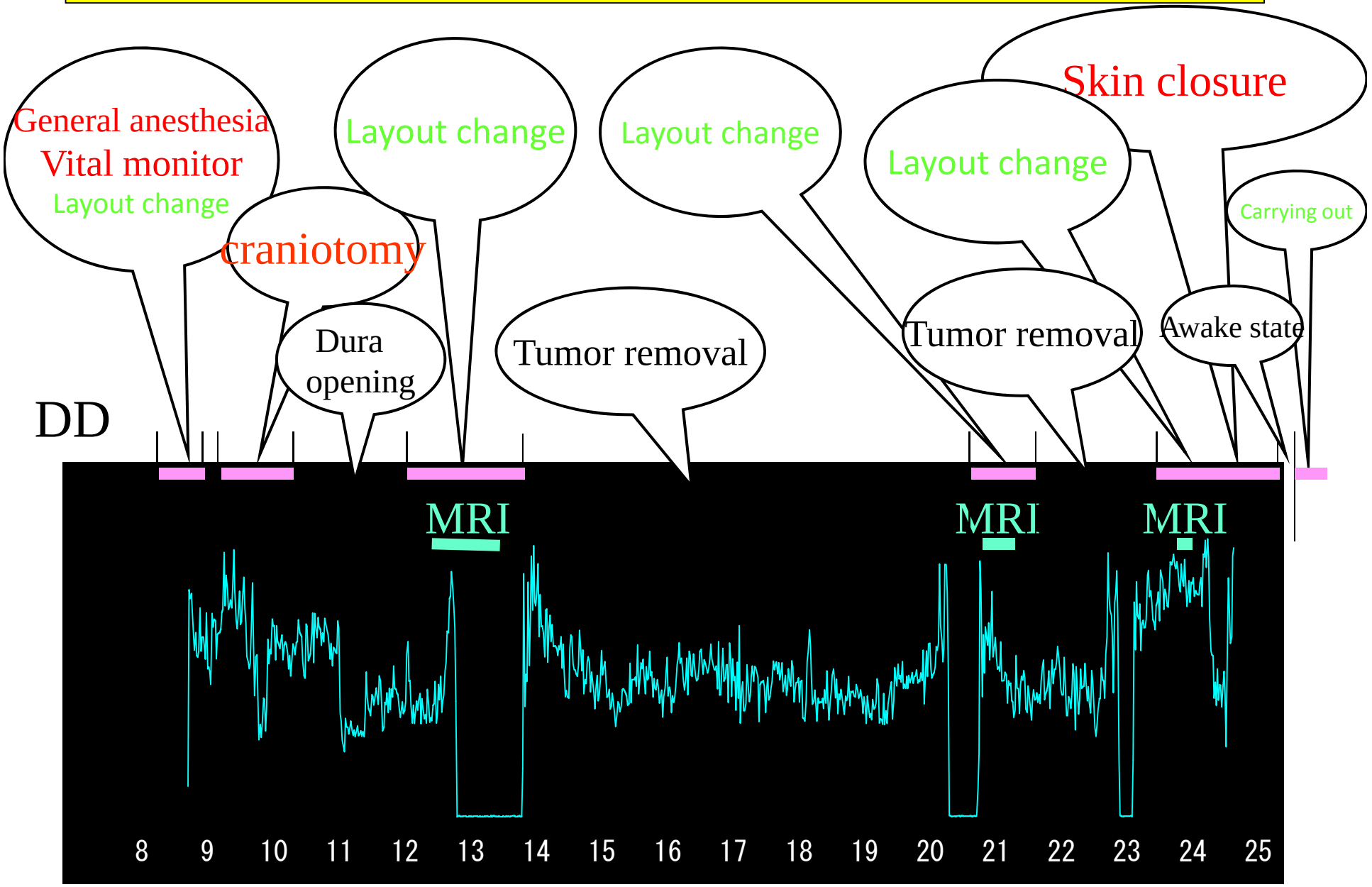

instrument table


navigator


Operating light


panoramic view

Compressibility of image & surgical process

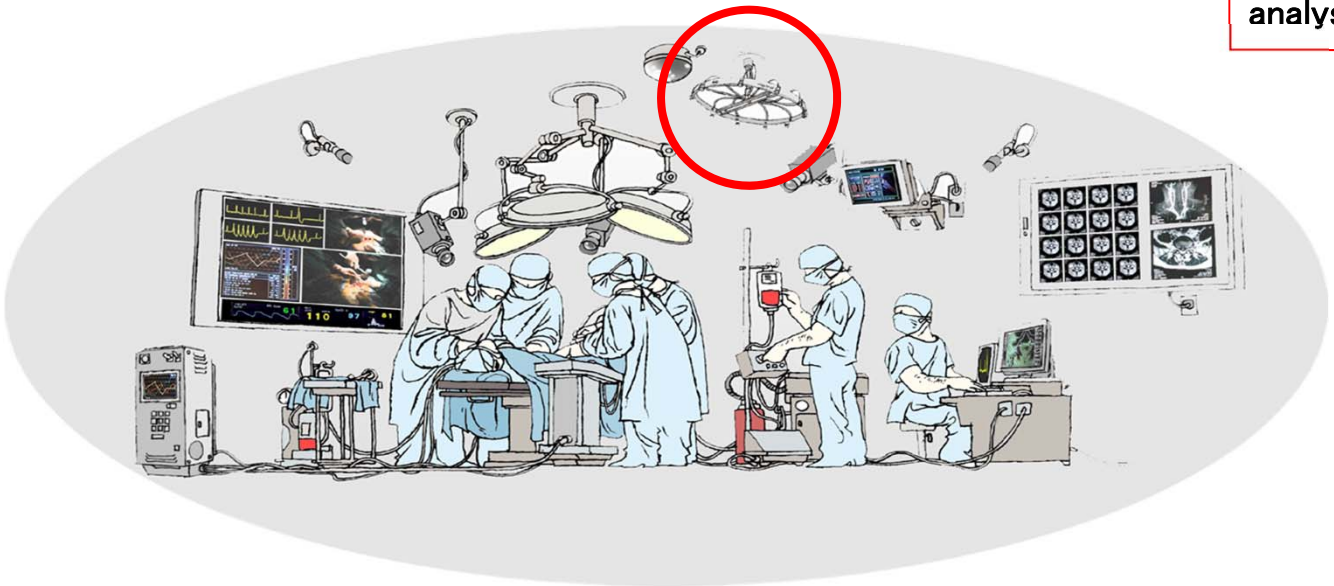


SCOT Function (Operating Theater System 3/11)

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.

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

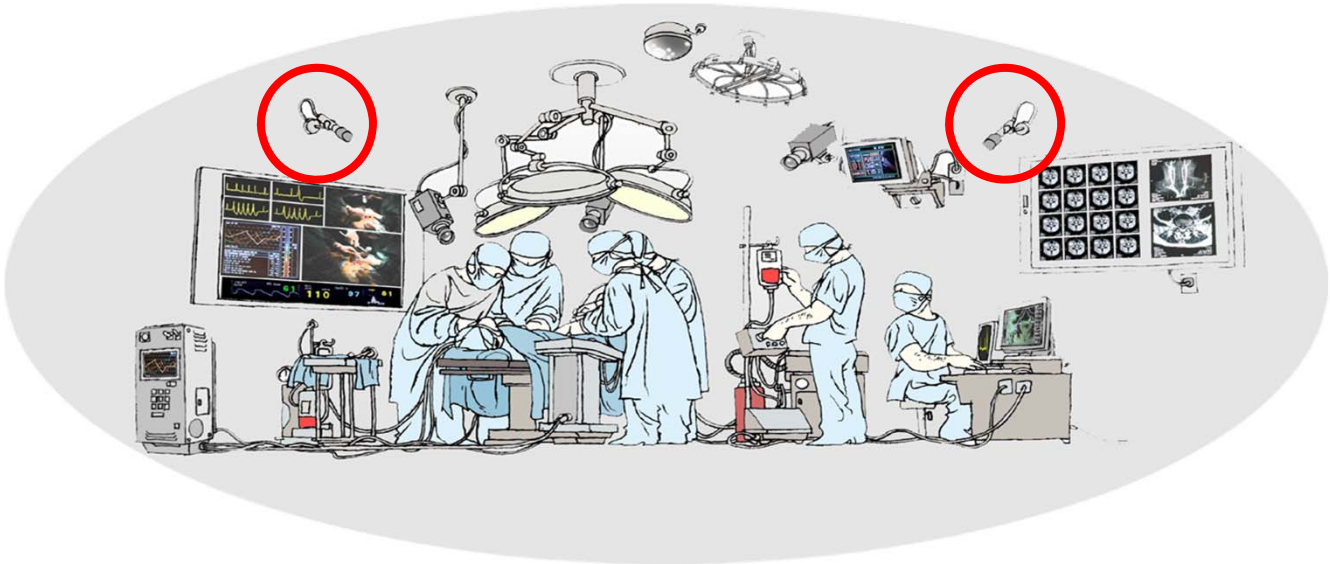


SCOT Function（Operating Theater System 4/11）

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

Surgical field sound recording → Surgical field sound → Sound signal processing → purpose sound extraction → sound → Surgical field information analysis system



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

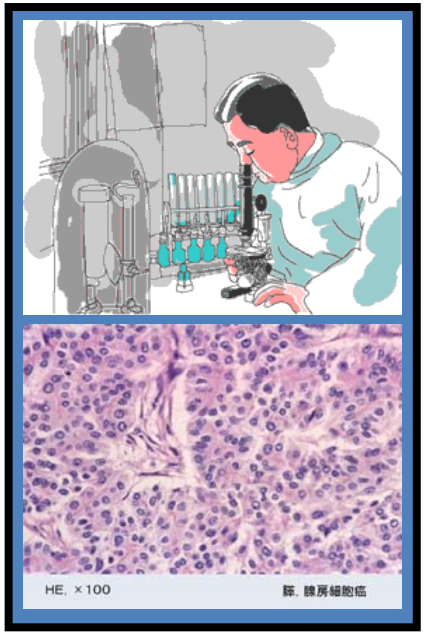
- Rapid analysis of the resected tissue is required for:
  - Discrimination of the neoplastic and normal tissue
  - Determination of tumor malignancy
- Possible improvement by combined use of several intraoperative histopathological techniques

Current Diagnostic Method

Tissue extraction

Resected tissue

Diagnosis by specialist

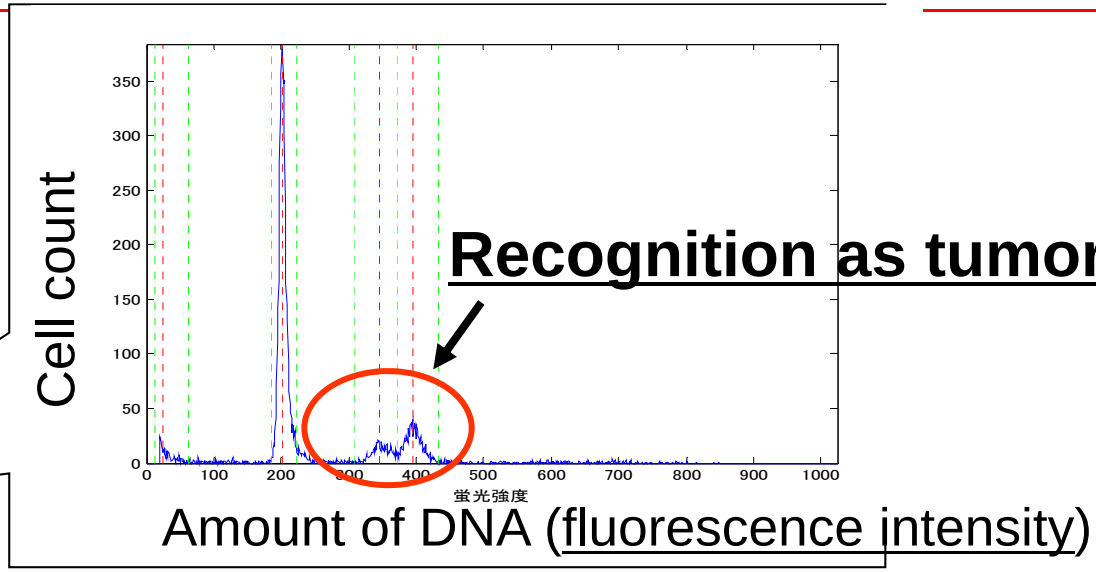


Diagnostic result

SCOT Function（Operating Theater System 5/11）

Extracted tissue rapid analysis system

- Automatic judgements on tissue grade-of-malignancy based on the evaluation of the DNA content
- Determination of tumor presence



flow cytometer application

Judgment in 8 minutes

SCOT Function（Operating Theater System 6/11）

Dynamic monitoring system

- It sets 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.

ME instrument setting content

ME instrument setting

ME instrument control information input

Patient dynamic phase Information recording

Wireless LAN connection

ME instrument Signal processing

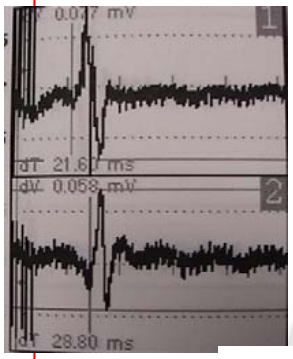
ME instrument information display

Vital sign

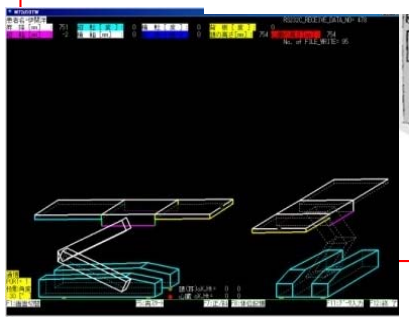
Surgical information analysis system

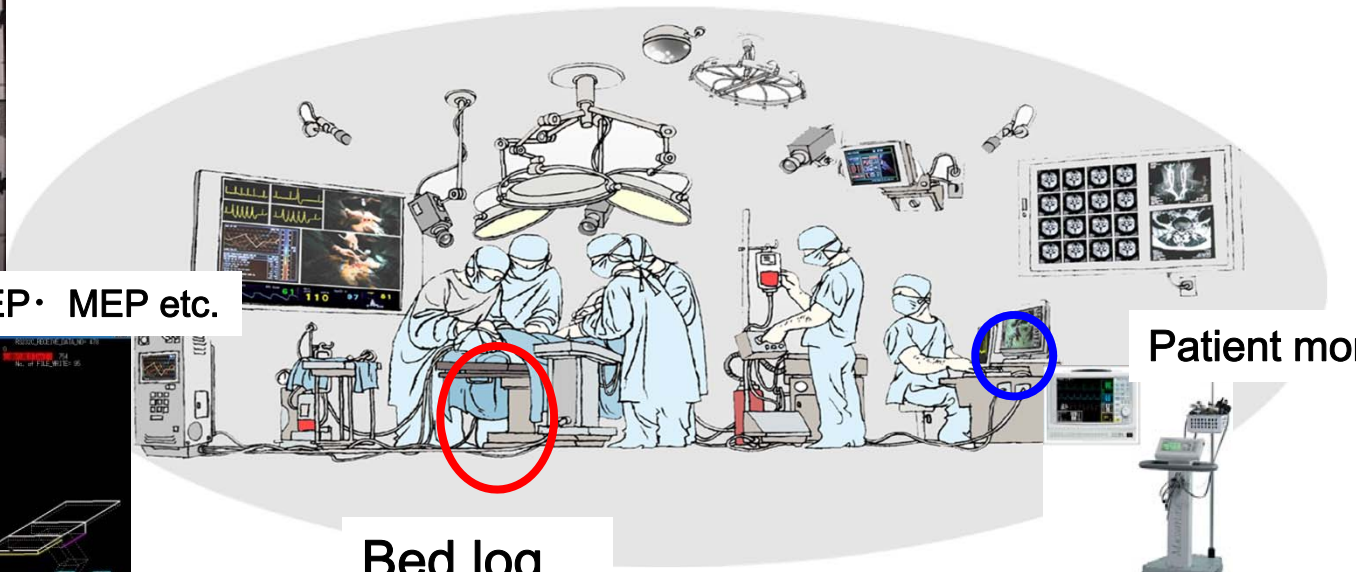
Vital sign

Vital sign



SEP・ MEP etc.





Bed log

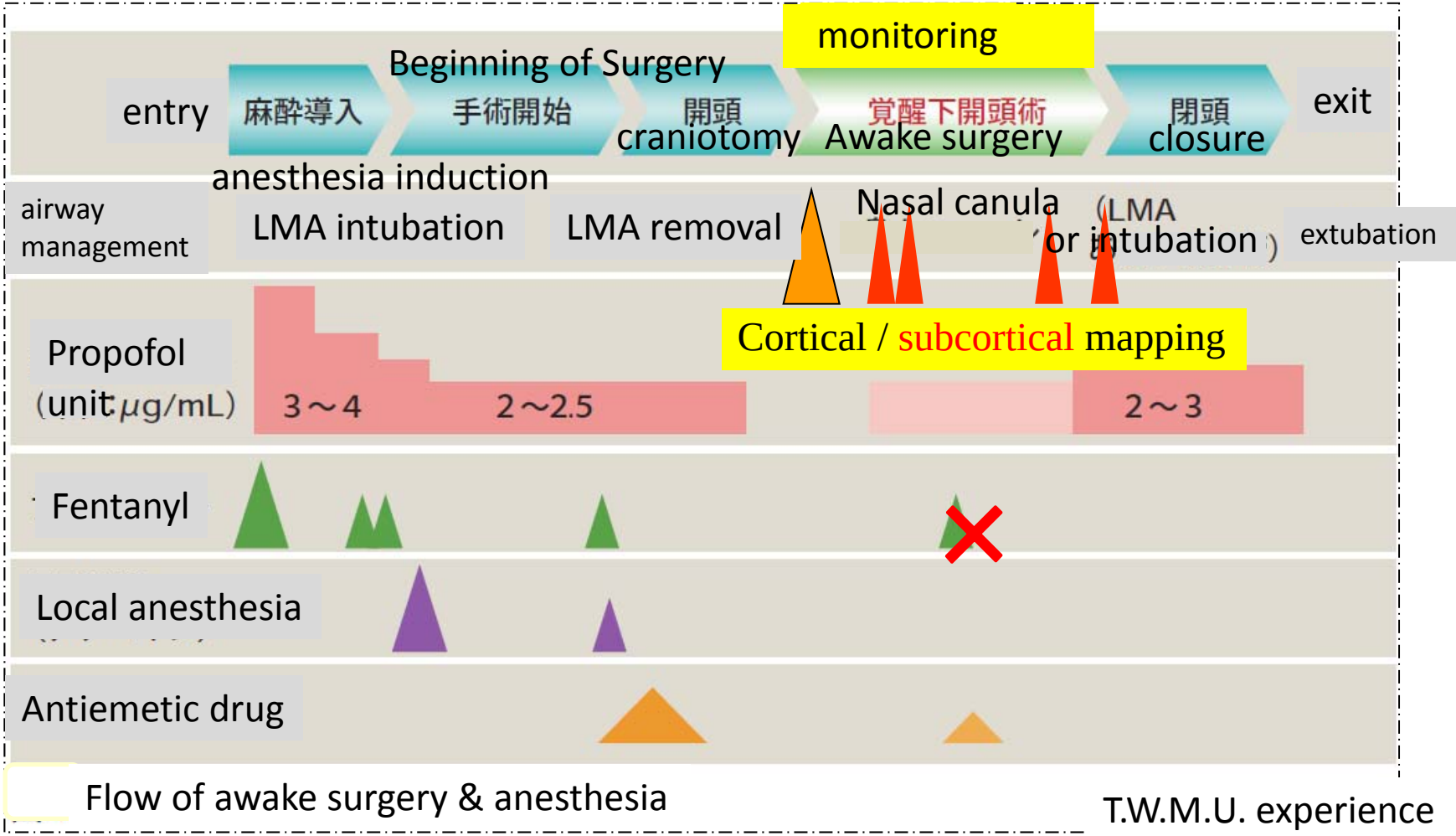
Patient monitoring

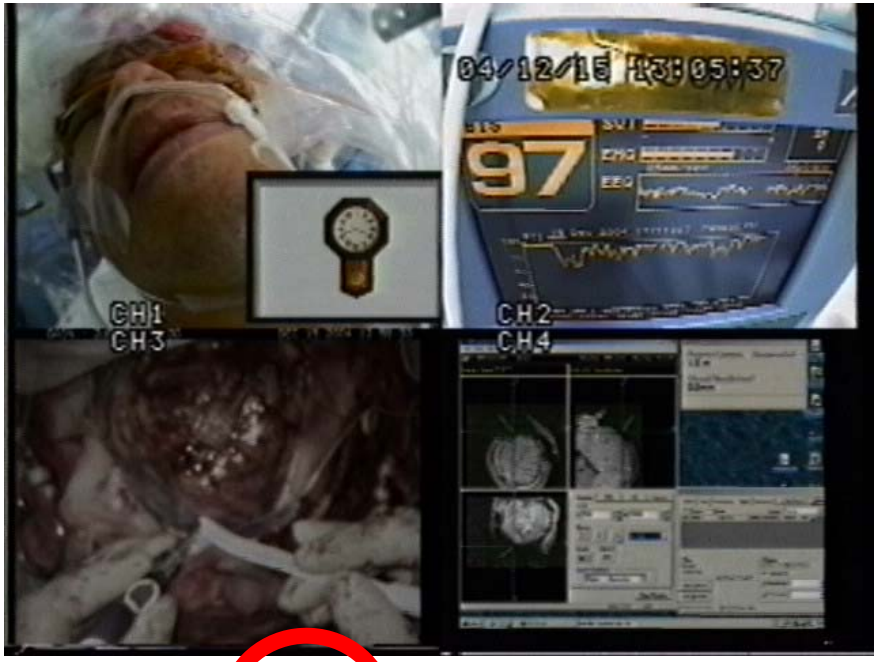
Awake surgery

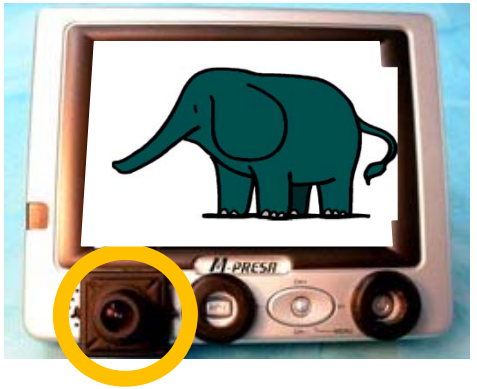
IEMAS 2

Methodology of awake surgery

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




04/12/15 13:05:37
97
CH1
CH3
CH2
CH4

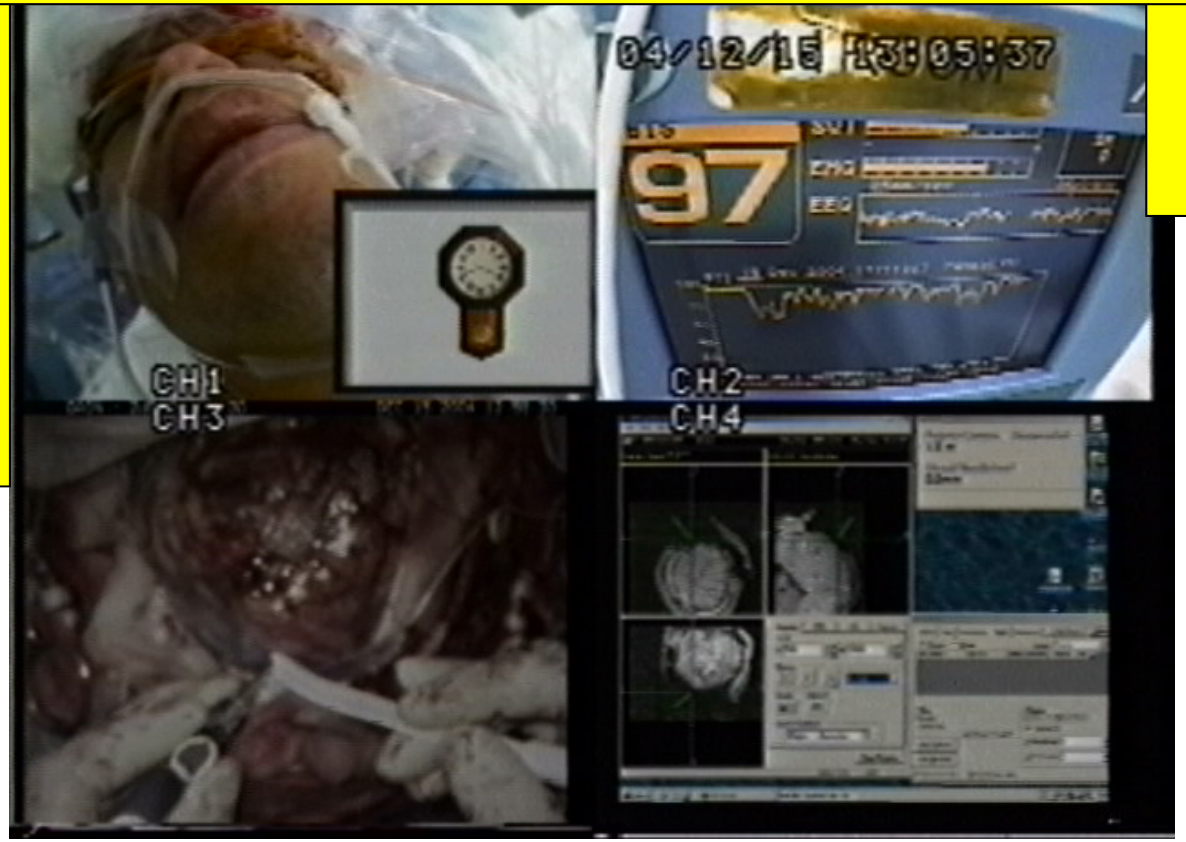

PRESA

Sharing information to prevent false positive responses

Functional information

Awake surgery &

Task



BIS monitor

Awake level

Functional information

Mapping of speech area

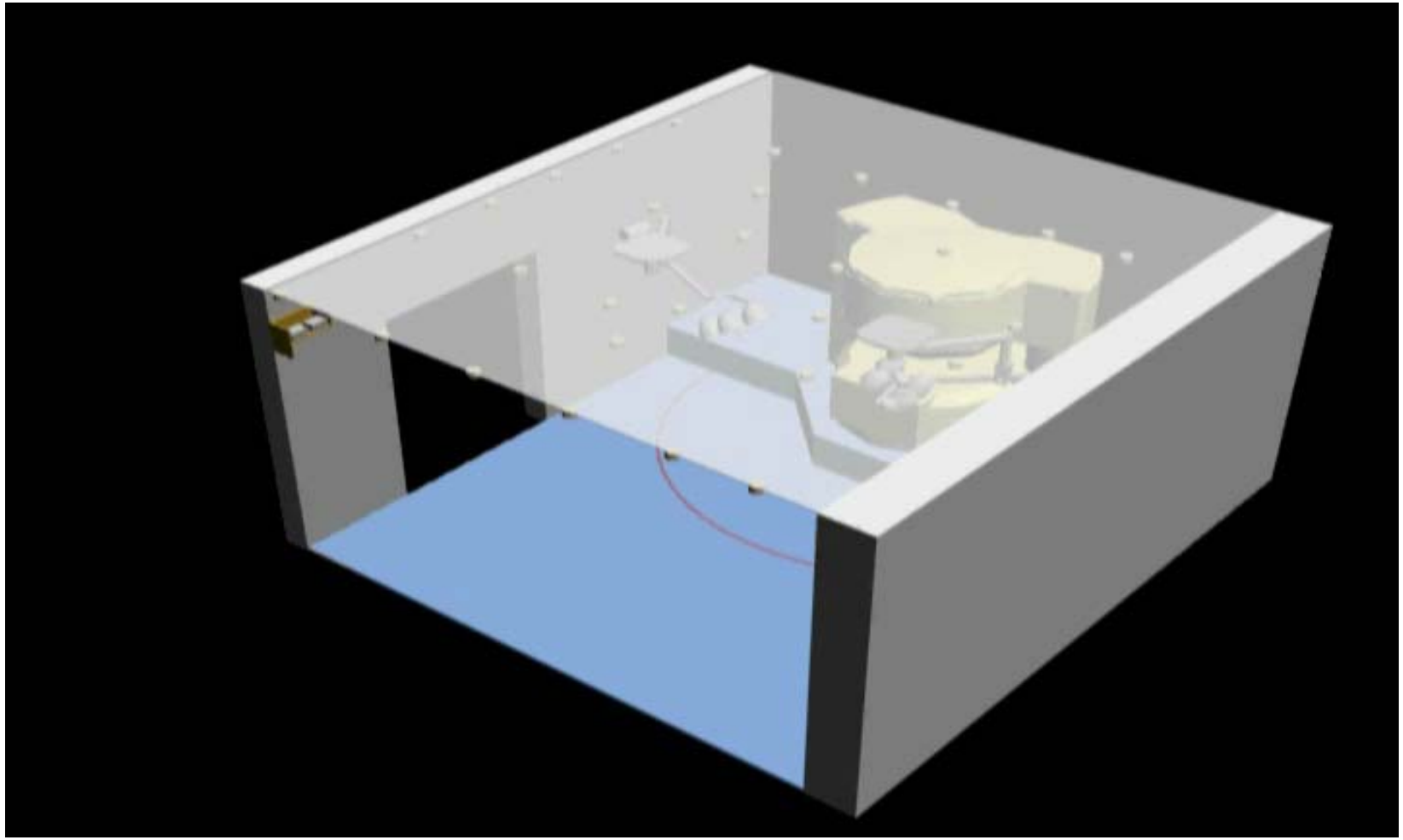
Anatomical information

Intraoperative MRI Navigation


(M) 39Y
22247164 BRAIN
3D GE RSSG 27/10.0 FA:30
TRS 230 3.0 HFS
256x160
S# 43/100
NSA 1
00:03:36
Ph
Scan 4 - 1 - 43
3DT1 T3mm
AI
1.00 X
AIRIS II
19:56
Folder
S, K
22247164
BRAIN
Tools
Series 1
900
Aa
First
No.

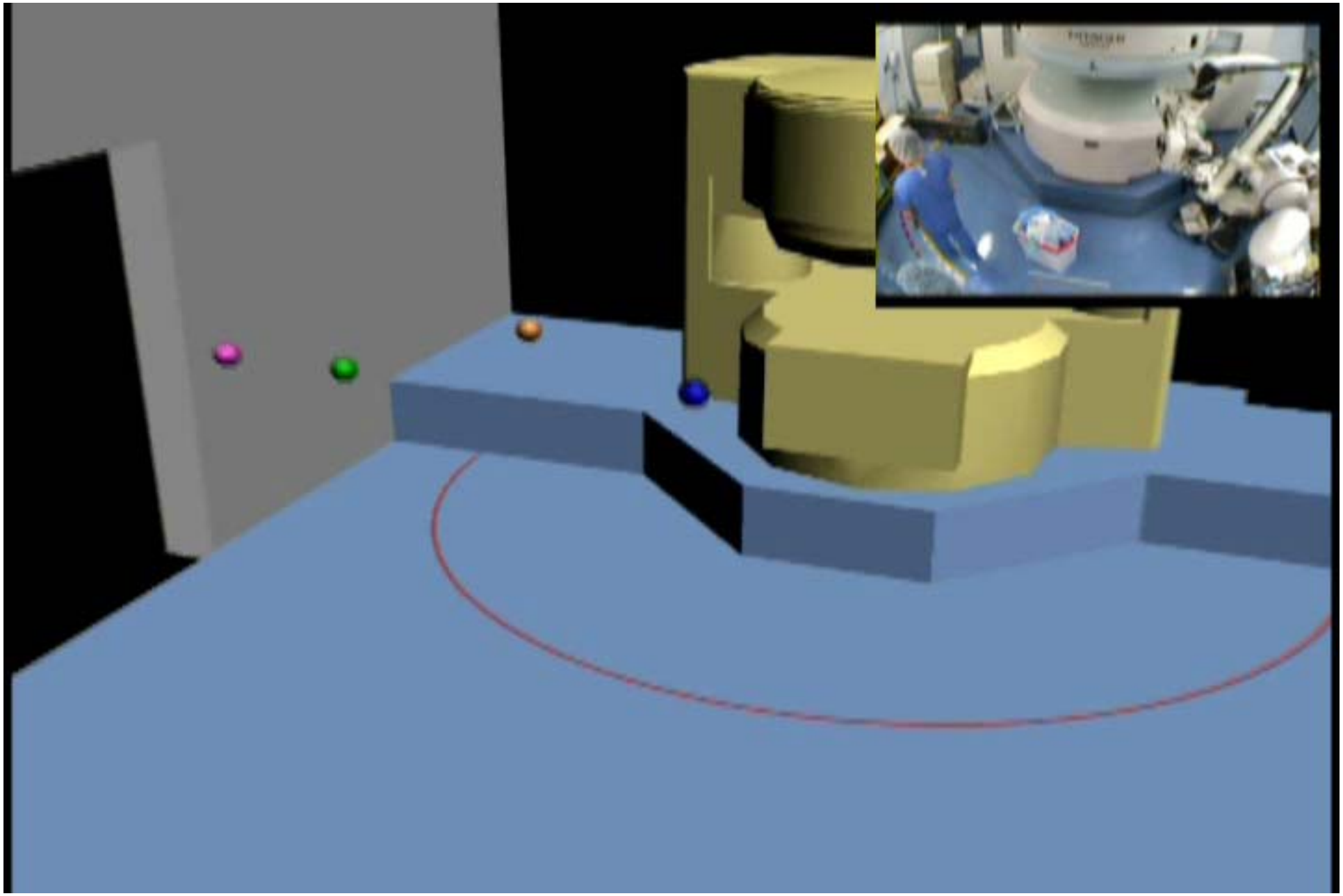
- Ultrasonic emission tag - microphone array
  - 4D information (3D position + time)

Recording of the Staff Position and Motion



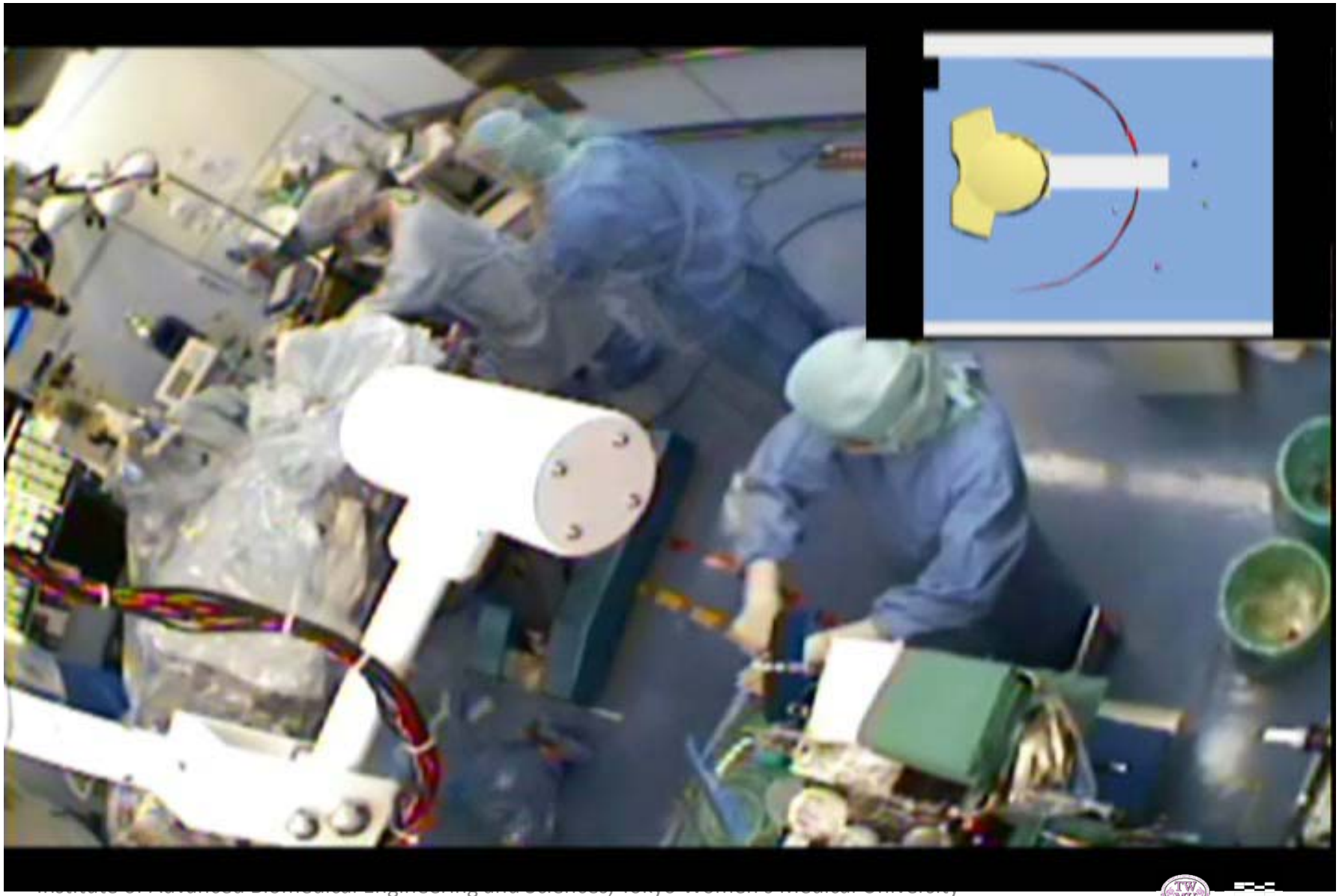
Institute of Advanced Biomedical Engineering and Sciences, Tokyo Women's Medical University

(Prof.Izumi, AIST, JAPAN)



(Prof.Izumi, AIST, JAPAN)

Motion of surgical staff



SCOT Function（Operating Theater System 10/11）

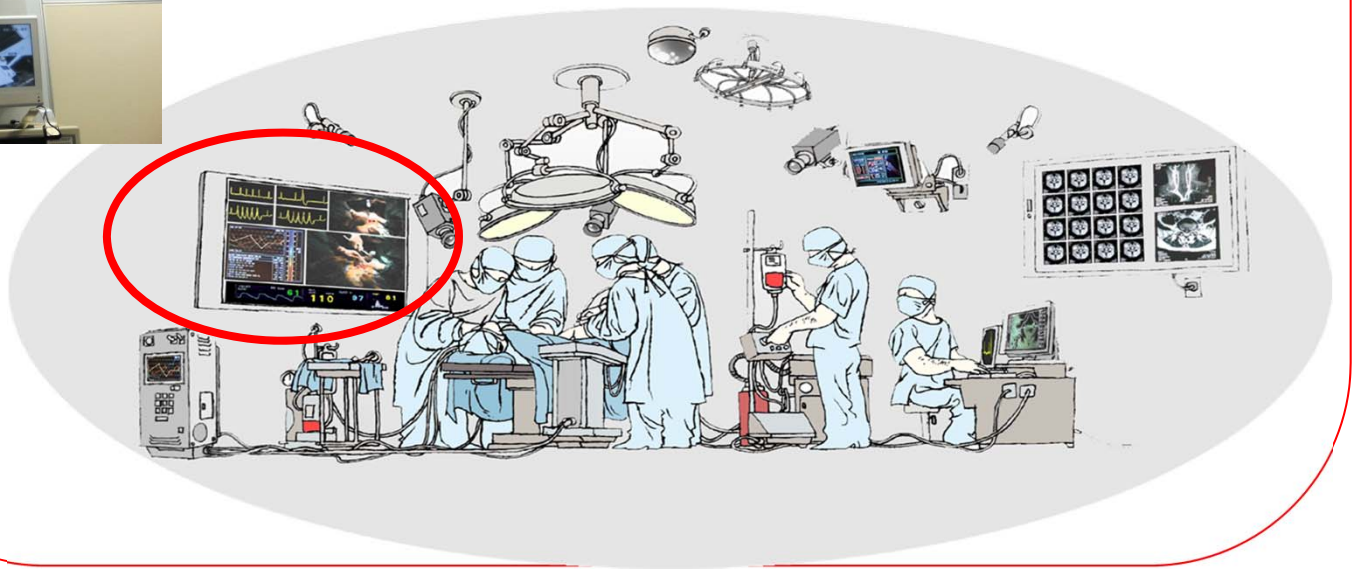
Operating theater information-display-system

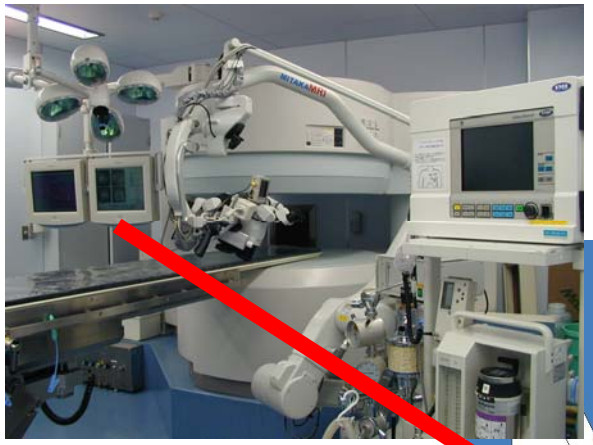
・It displays information collected and generated by the operating theater system and the strategy desk system.

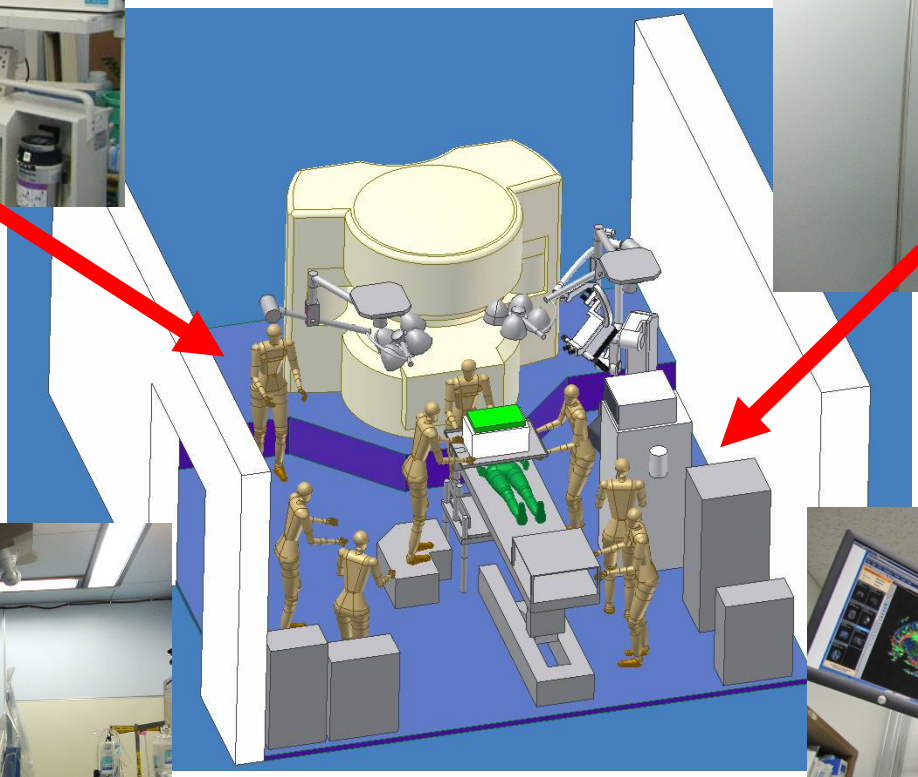
・The content of displayed information is chosen automatically according to the needs of surgical situation.

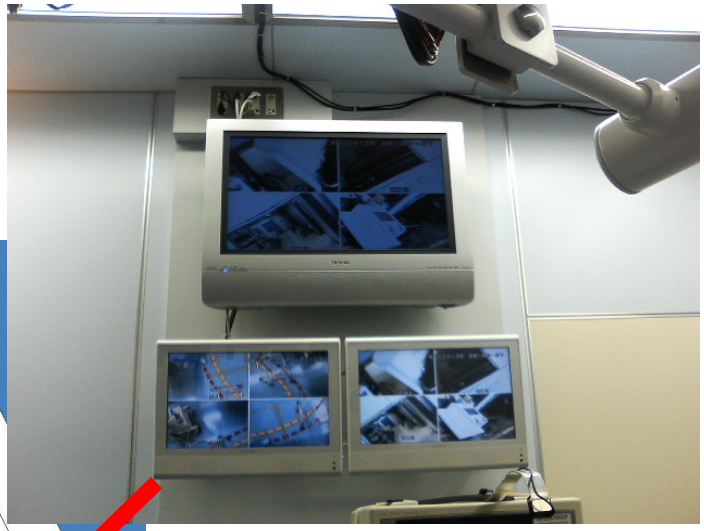
displayed information from backbone network

display-screen choice → screen choice → **display-screen control** → display information → **displaying information**







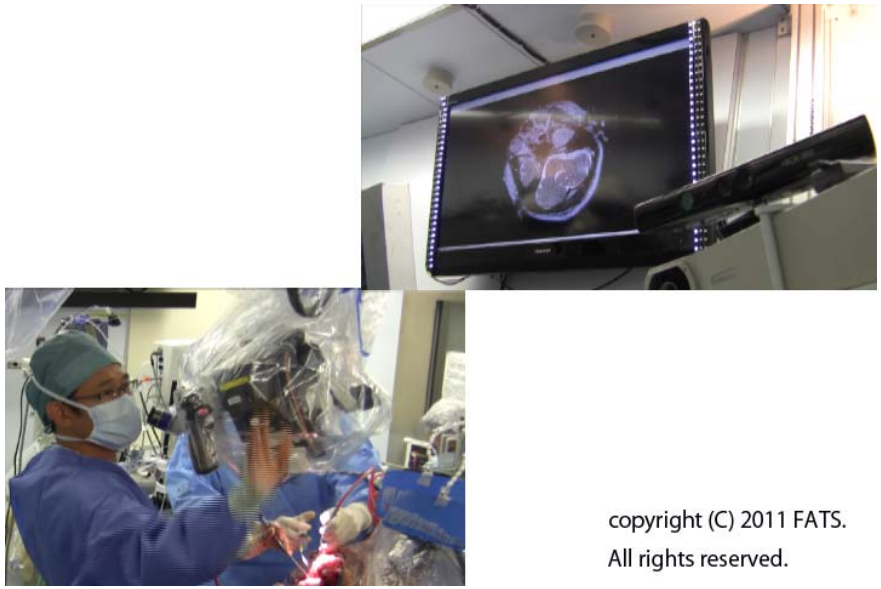


Medical staff within and outside of the operating theater sharing all intraoperative information

Strategy desk

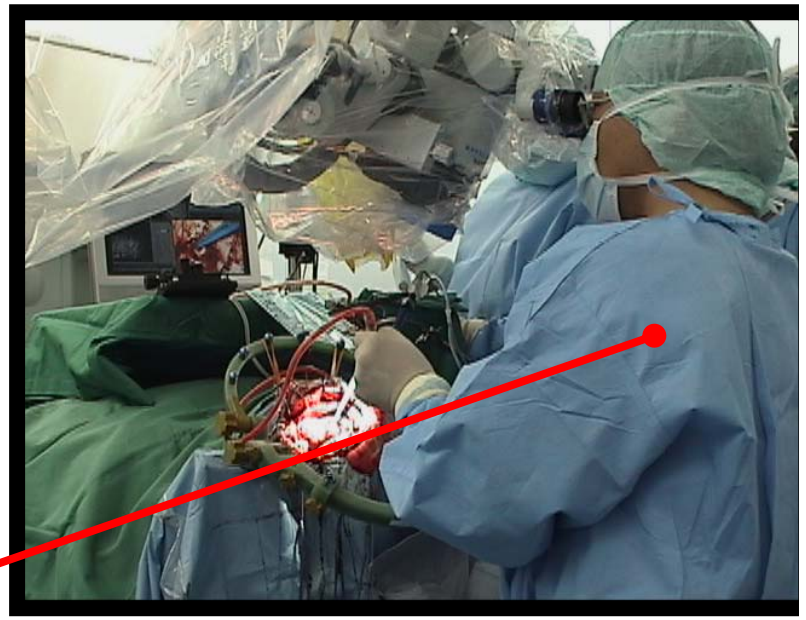
The monitor display-screen non- contact control system

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)

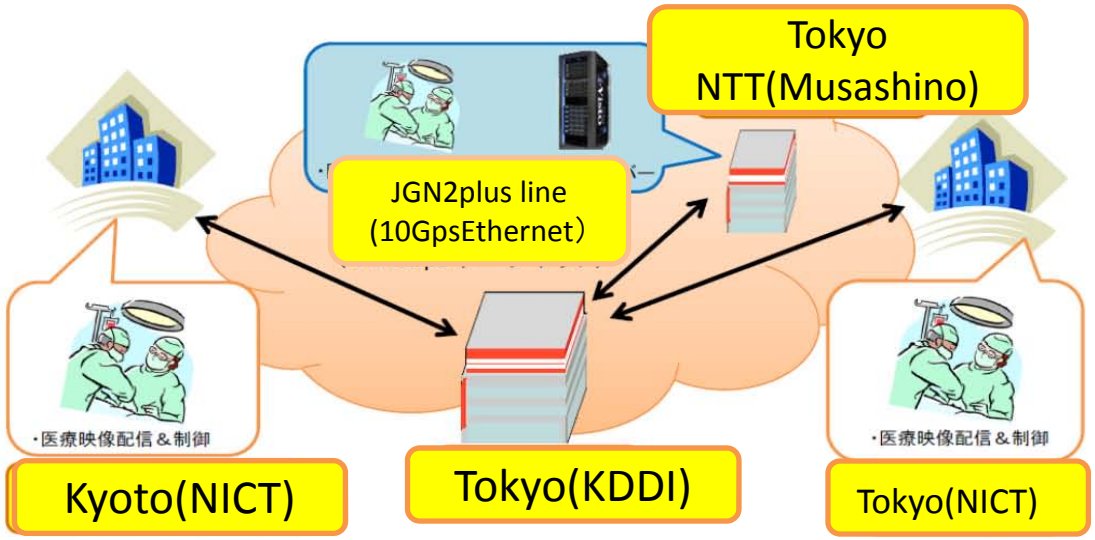
JGN2plus line
(10GpsEthernet）

Kyoto (NICT institute)

10Gbps
Fixed-line

10Gbps
Fixed-line

Tokyo
(NICT head office)



c.a. 520km

2011.2.4.(Friday)

SCOT Function（Operating Theater System 11/11）

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.**

IEMAS

Strategy desk

THz wireless

node

10Gps fixed line

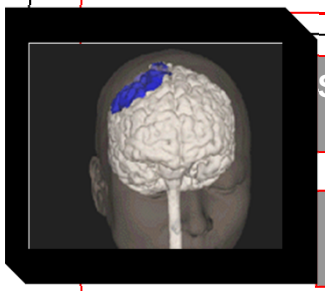
Ultra high-definition image（**4K video**）Incompressibility transmission

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.



Surgical planning

Surgical planning input

Surgical planning validation

Validation result

To Surgical information server

Surgical record

Surgical record Retrieval / input

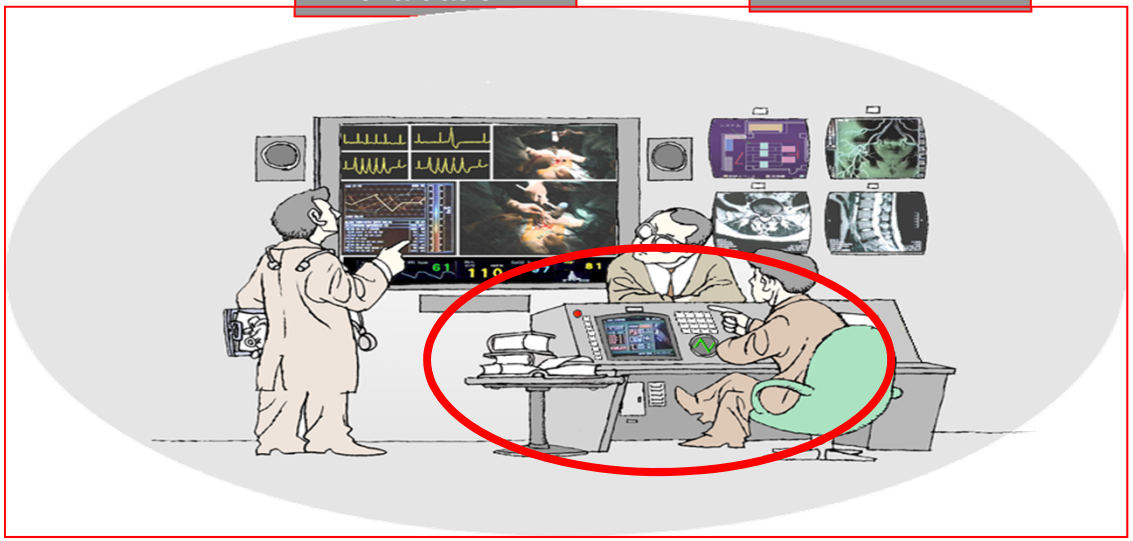
Surgical record evaluation

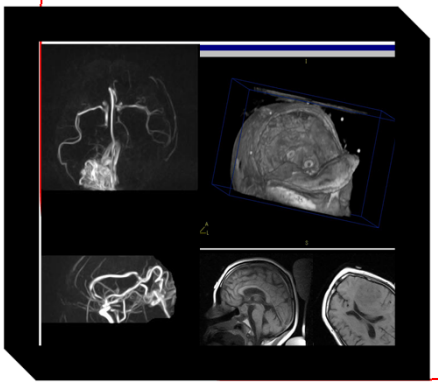
Evaluation result

Surgical result creating

Surgical result

To Surgical information server



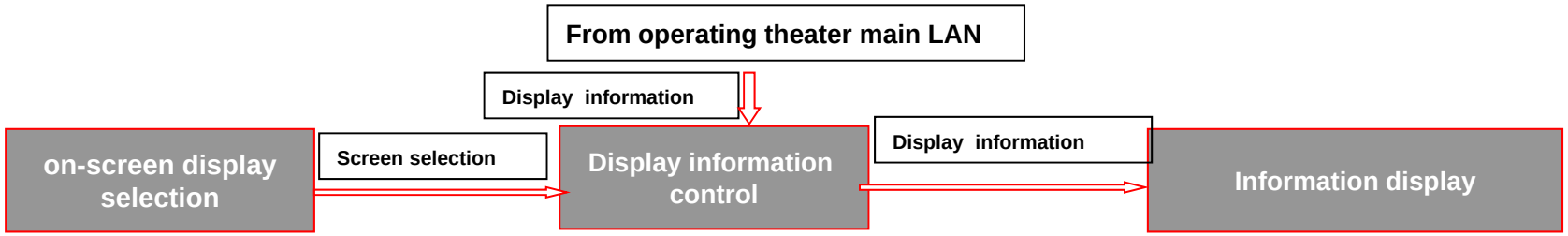


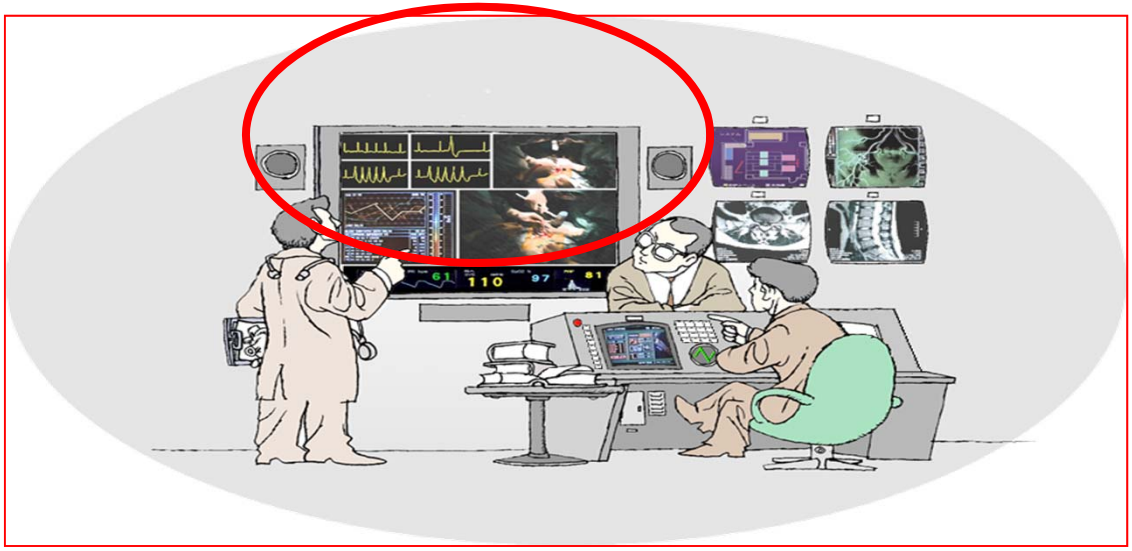
SCOT Function（Strategy Disc System 3/4）

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.



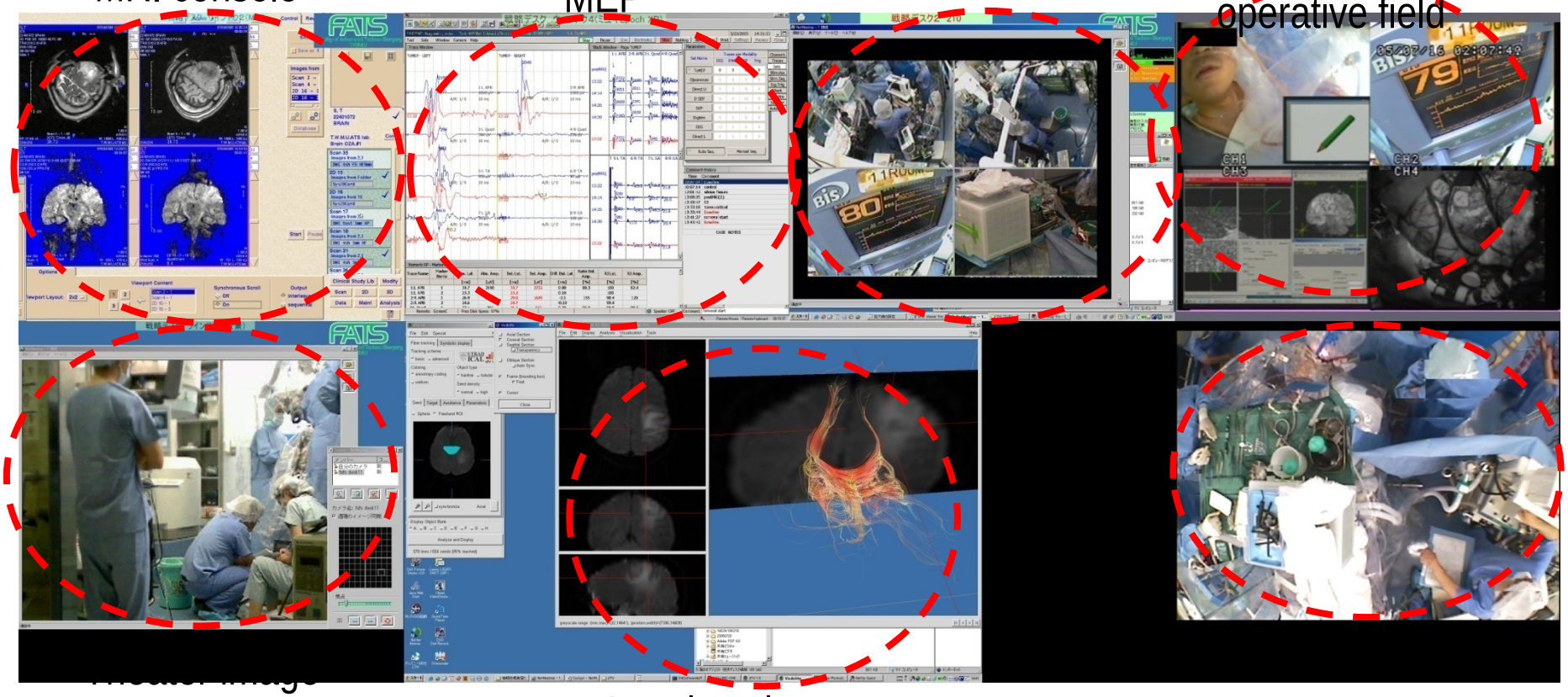


Strategy desk

MRI console

MEP

pateint・BIS・navigtion・
operative field



Local workspace
(preperative images etc.)

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

Strategy desk

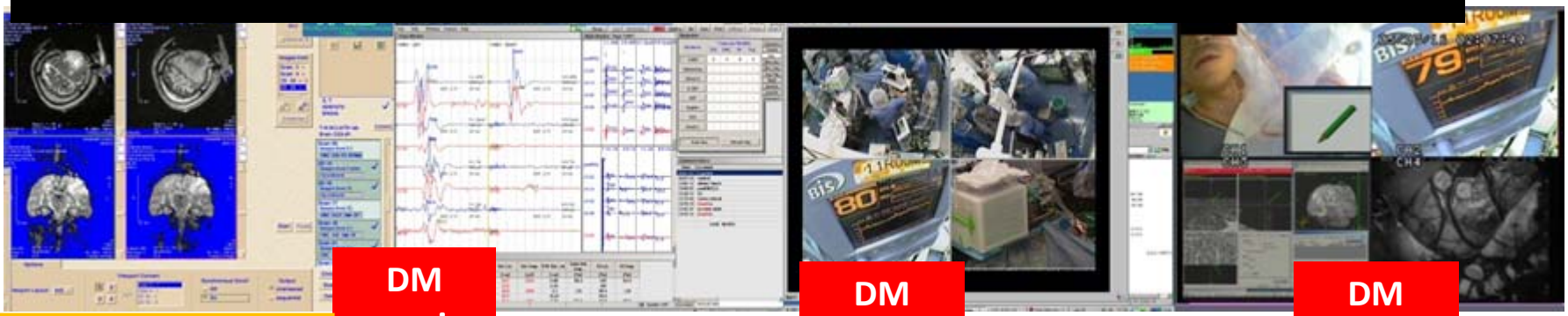
pateint ▪ BIS ▪ navigtion ▪

Start point

Target (outcome)

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

8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



DM navi

DM navi

DM navi

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

Necessary resource

fluctuation

- ・job finished benchmark
- ・difference from allowed time
- ・divergence from goal
- ・risk assessement

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.

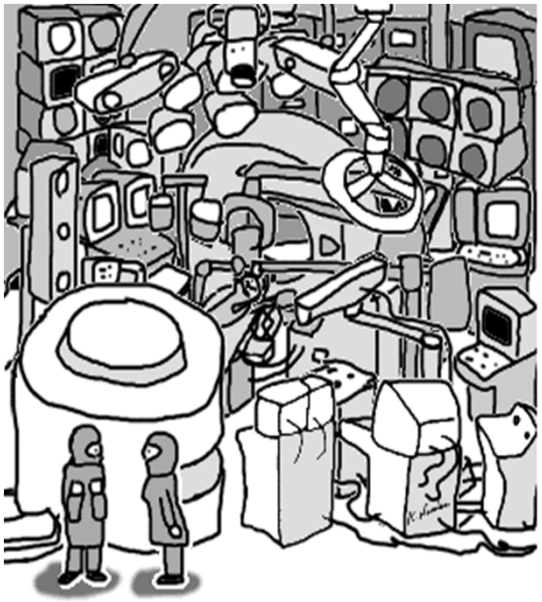
Avoidance of failures during recording of the information.

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.



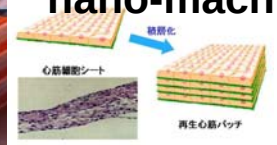
No, the patient didn't come.

Advanced Medicine based on grand sum of nano-tech, bio-tech, high-tech and so on.

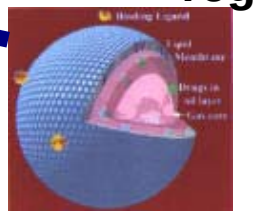
Future medicine

Nano-bio interface

nano-machine therapy

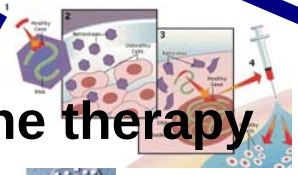


regenerative medicine



DDS

tip technology



gene therapy

high-tech medicine
（robotics, artificial organ）

Chemical IC

Center for advanced Biomedical Science 15th. March,2008-

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

Acknowledgement

This study is granted by the Japan Society for the Promotion of Science (JSPS) through the "Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)," initiated by the Council for Science and Technology Policy (CSTP).

NanoBio

Thank you very much for your kind attention!

Kiitos!!

You are always welcome in our Institute!

Google FATS search

FATS
Faculty of Advanced Techno-Surgery
TWMU