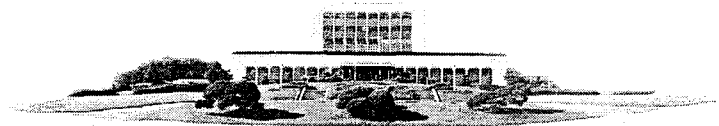# 초청 강연 V

MCG를 이용한 심근전류 매핑 및 심근허혈 진단

- 좌장 | 삼성서울병원 김영욱

- 표준(연) 이용호

MCG를 이용한 심근전류 매핑 및 심근허혈 진단

이 용 호
한국표준과학연구원
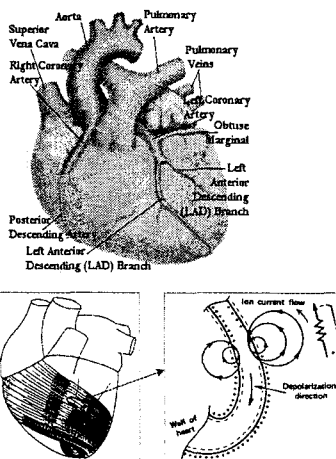생체자기계측센터

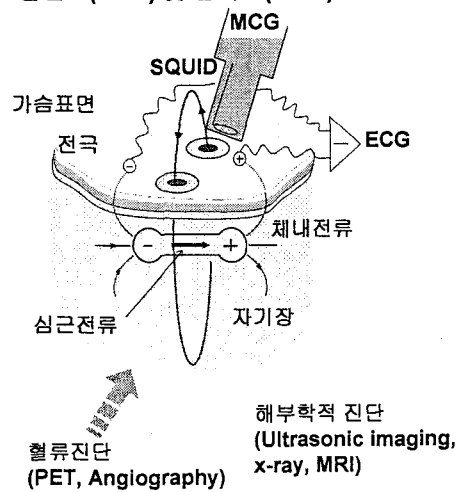Korea Research Institute of Standards and Science
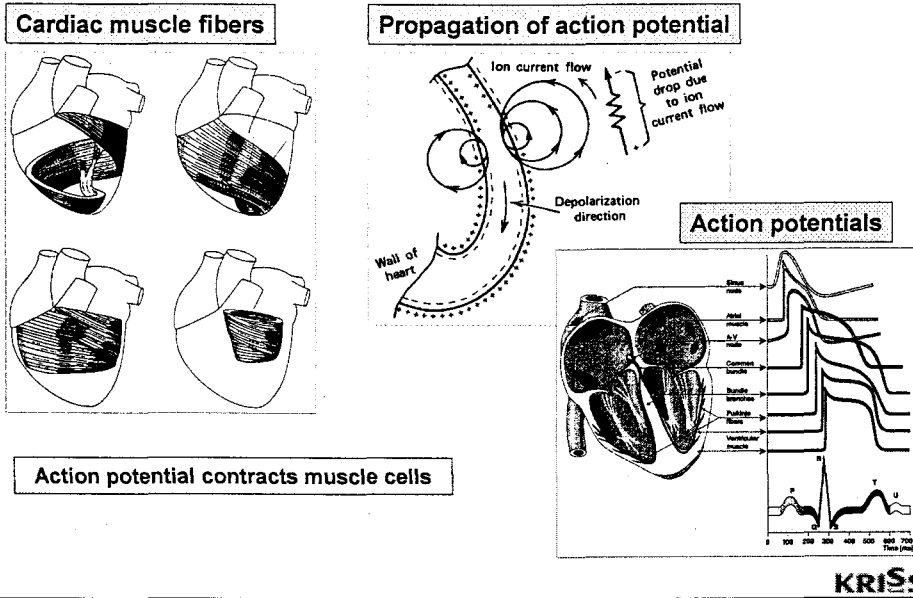
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ECG and MCG
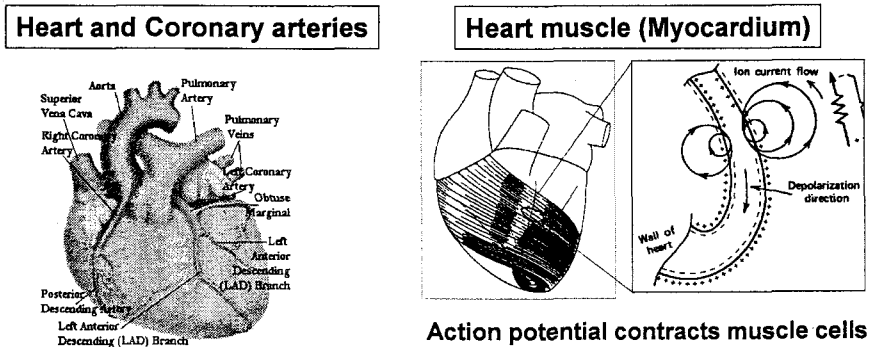
관상동맥 및 심근세포

심근전류 → 심장의 수축과 이완

심전도(ECG) 및 심자도(MCG)

혈류진단
(PET, Angiography)

해부학적 진단
(Ultrasonic imaging,
x-ray, MRI)

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Electric activation of cardiac muscle cell

Cardiac muscle fibers

Propagation of action potential

Action potentials

Action potential contracts muscle cells

Heart – Blood pump

Heart and Coronary arteries

Heart muscle (Myocardium)


Action potential contracts muscle cells

Ischemia – Insufficient blood supply

Cellular level electromagnetic changes
- Decrease of the resting transmembrane potential
- Decrease of action potential amplitude and morphology
- Decrease and inhomogeneity of electrical conduction
    → Change in magnetic field pattern (: Magnetocardiogram)

Noise reduction

Magnetically shielded room

E-M wave

Gradiometer

Magnetic field
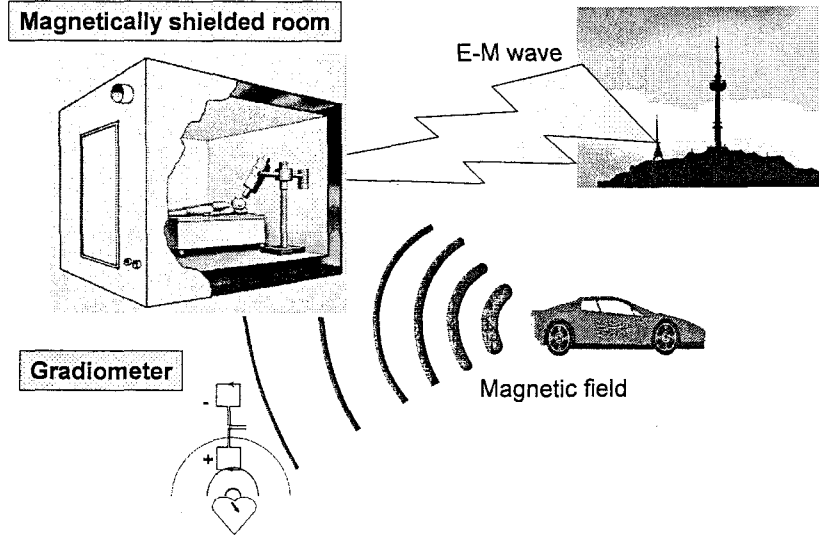
Applications of MCG

- **Ischemia**
  - 재분극 전류가 심실표면에 평행
  - 허혈성 심근 및 경색 후 소생 가능한 심근조사
  - Stress MCG : ST shift

- **Risk analysis**
  - 심실세동
  - ST interval/QT dispersion : fragmentation
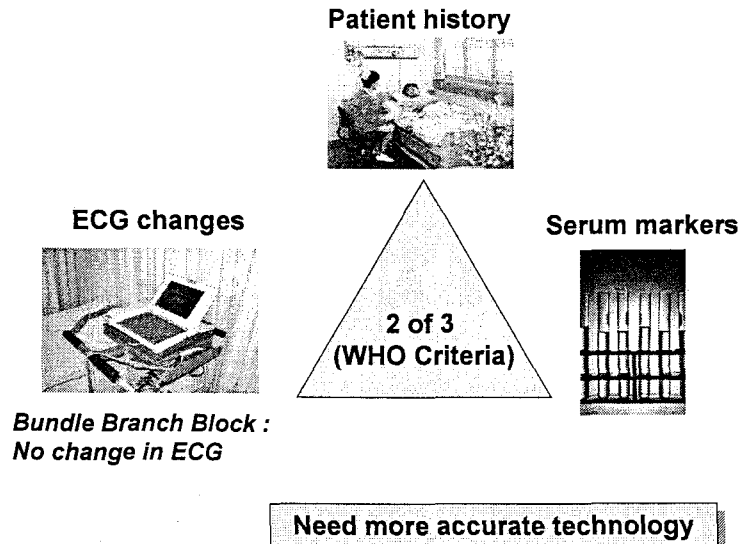 - Late field : 정상/경색의 경계부분

- 비정상 전기전도 위치추정
  - 심실빈맥/WPW 증후군 : 부수적인 전도경로의 위치추정

- **Fetal MCG**
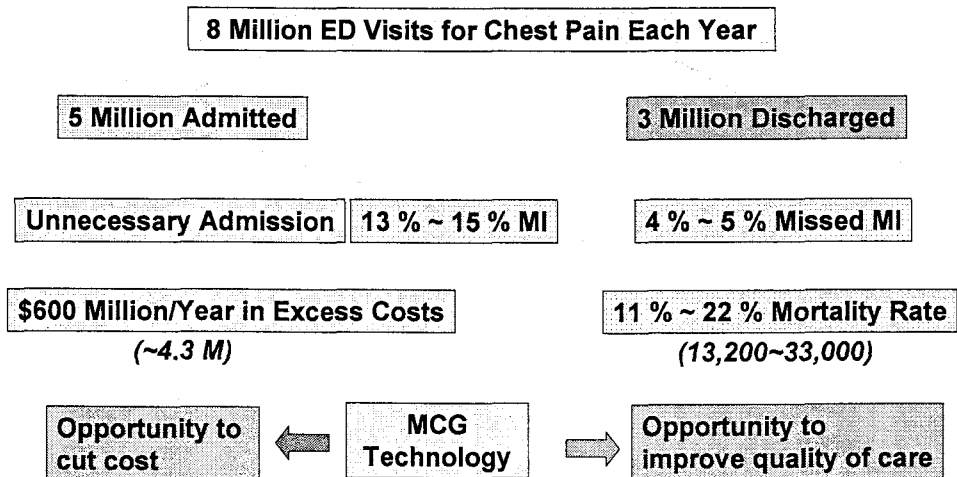 - 자율신경계 조사

Decision of acute coronary syndrome (ACS)

Patient history

ECG changes

Serum markers

2 of 3
(WHO Criteria)

Bundle Branch Block :
No change in ECG

Need more accurate technology

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Acute chest pain (USA)

8 Million ED Visits for Chest Pain Each Year

| 5 Million Admitted | | 3 Million Discharged |

| Unnecessary Admission | 13 % ~ 15 % MI | | 4 % ~ 5 % Missed MI |

$600 Million/Year in Excess Costs
(~4.3 M)

11 % ~ 22 % Mortality Rate
(13,200~33,000)

| Opportunity to cut cost | ⇦ | MCG Technology | ⇨ | Opportunity to improve quality of care |

MI : Myocardial infarction

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MCG in Coronary artery disease

Magnetocardiography predicts coronary artery disease in patients presenting with acute chest pain

J.W. Park, Hoyerswerda, Germany

n=185 patients (CMI MCG-2409)

Conclusion: In patients with acute chest pain and without ST-segment elevation MCG predicted CAD with a 97.8% probability and excluded CAD with a 84.8% probability. The value of unshielded MCG in clinical routine is limited due to poor signal quality in a significant number of patients (23.9%).

EUROPEAN
SOCIETY OF
CARDIOLOGY

ICU

	AUT	R1	R2	ECG (n=160)	Trop I (n=185)	Echo (n=184)
		MCG (n=185)				
Specificity	82.5%	92.8%	76.2%	91.1%	90.5%	76.2%
Sensitivity	86.4%	95.1%	88.7%	33.9%	42.7%	51.0%
NPV	63.5%	84.8%	66.7%	27.4%	31.7%	31.4%
PPV	94.5%	97.8%	92.6%	93.3%	93.8%	87.9%

ESC Congress 2004

28 August 2004 - 01 September 2004

Munich, Germany

http://cic.escardio.org/AbstractDetails.aspx?id=13845

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MCG vs. ECG in ischemia

Advantages of MCG

- **More sensitive to tangential currents**

- **Sensitive to vortex (rotating) currents (ECG is not)**

- **Detects better current flow between endocardium and epicardium**

- **Less dependent on conductance variation outside the heart**

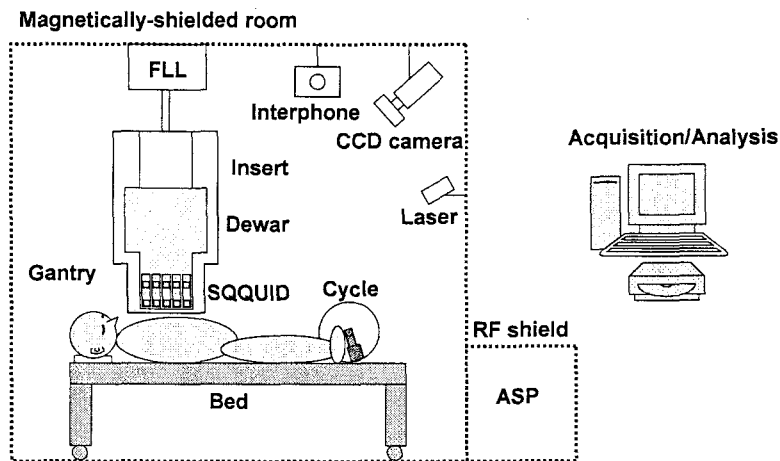- **Fully non-contact (no skin-electrode problems) and non-invasive**

Limitations of ECG in Ischemia

- **Relatively high specificity for selected ECG findings**

- **But, low sensitivity in general**

- **Unrecognized MI (myocardial infarction) in ECG : 4~44 %**

Am Heart J 2004;148:277–84

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MCG system

Magnetically-shielded room

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Technical Tasks

► Amplitudes of MCG signals : ~ 100 times larger than brain signals

However, disease-specific signal components are small in amplitude

→ Good signal-to-noise ratio is still necessary

► Conventional MCG systems are bulky and less economical

→ Economic, yet, effective MCG system is necessary

► How can we get useful information from the MCG?

i) Find specific features in the MCG data for each specific diseases

ii) Quantify these signatures using characteristic factors

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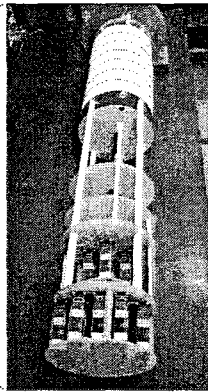# SQUID system
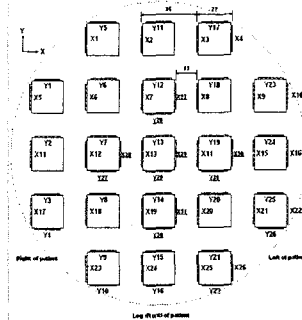
SQUID (Superconducting Quantum Interference Device)
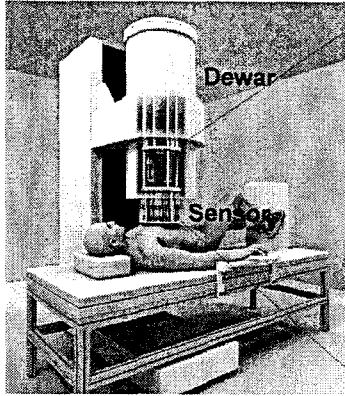
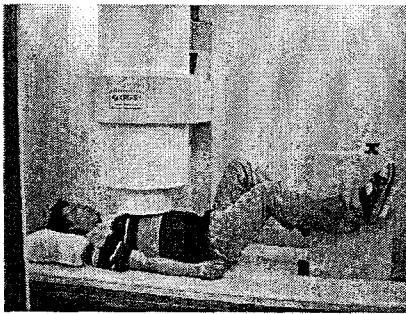| Measuring system | Insert | Sensor distribution |

64 sensing channels
Sensor interval : 22-35 mm
Cover area : 162 mm x 162 mm

► Sensor coverage is smaller than the conventional vertical measurements,
but it is large enough to get the essential field distribution

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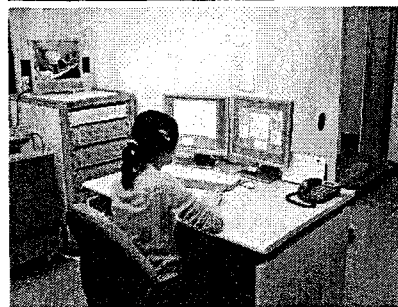# Operation in Heart Center

| Dewar/Gantry/Bed | Control/Acquisition |

- Positioning laser beam
- Load-adjustable, nonmagnetic cycle
- Movable bed and gantry
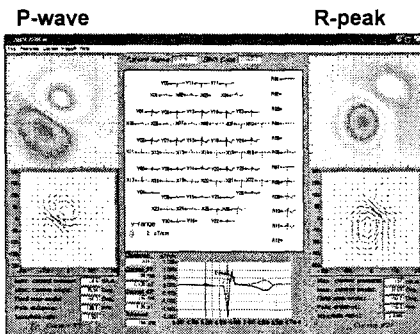
Shielding factor (MSR) :
40 dB @ 0.1 Hz, 75 dB @ 10 Hz

- Compact readout electronics
- Acquisition/Analysis by single PC
- Patient monitoring
- 64ch A/D card (16 bits)

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Signal processing
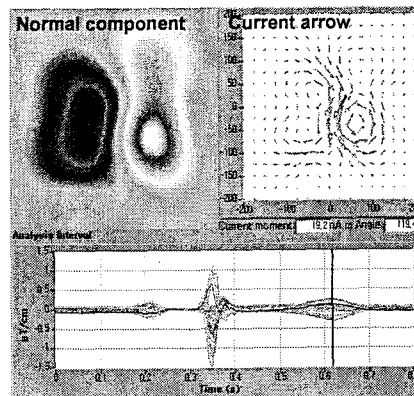
Acquisition/Analysis software

P-wave   R-peak

- Averaging
- Digital & Morphological filtering
- Field mapping
- Current arrow map using MNE
- Transform tangential to normal

Field & Current map

Normal component   Current arrow

- Direction and magnitude of current vector
- Depth of main current distribution
- Temporal stability of current distribution

KRI**S**S

Data analysis : ST-interval

- The **ST-T interval** is very suitable to be analyzed by the MCG, because:
  - The MCG is especially sensitive to tangentially spreading currents
  - The currents during ventricular repolarization are tangentially spreading currents
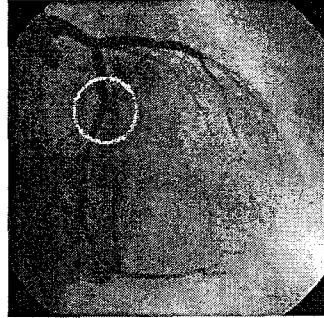
- ST-T interval → Well reflects myocardial ischemia

KRI**S**s

Comparison with Coronary angiography

Stable angina pectroris
MCG score : 3

Prox. LAD : 70 % stenosis
1ˢᵗ diagonal : 80 % stenosis

Non ST-segment elevation MI
MCG score : 2

Prox. LCX : 90 % stenosis

KRISs

Discussion

- MCG provides information on myocardial currents

- Quantitative analysis of ventricular repolarization parameters
  → Detect ischemia in patients with apparently normal ECG
  → Early, quick & non-invasive screening of CAD with acute chest pain

- What is golden standard?
  - Coronary angiography?

KRISs