Wireless monitoring in the OR: Future or Utopia ?

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Center of interests

- Scientific Advisory Board

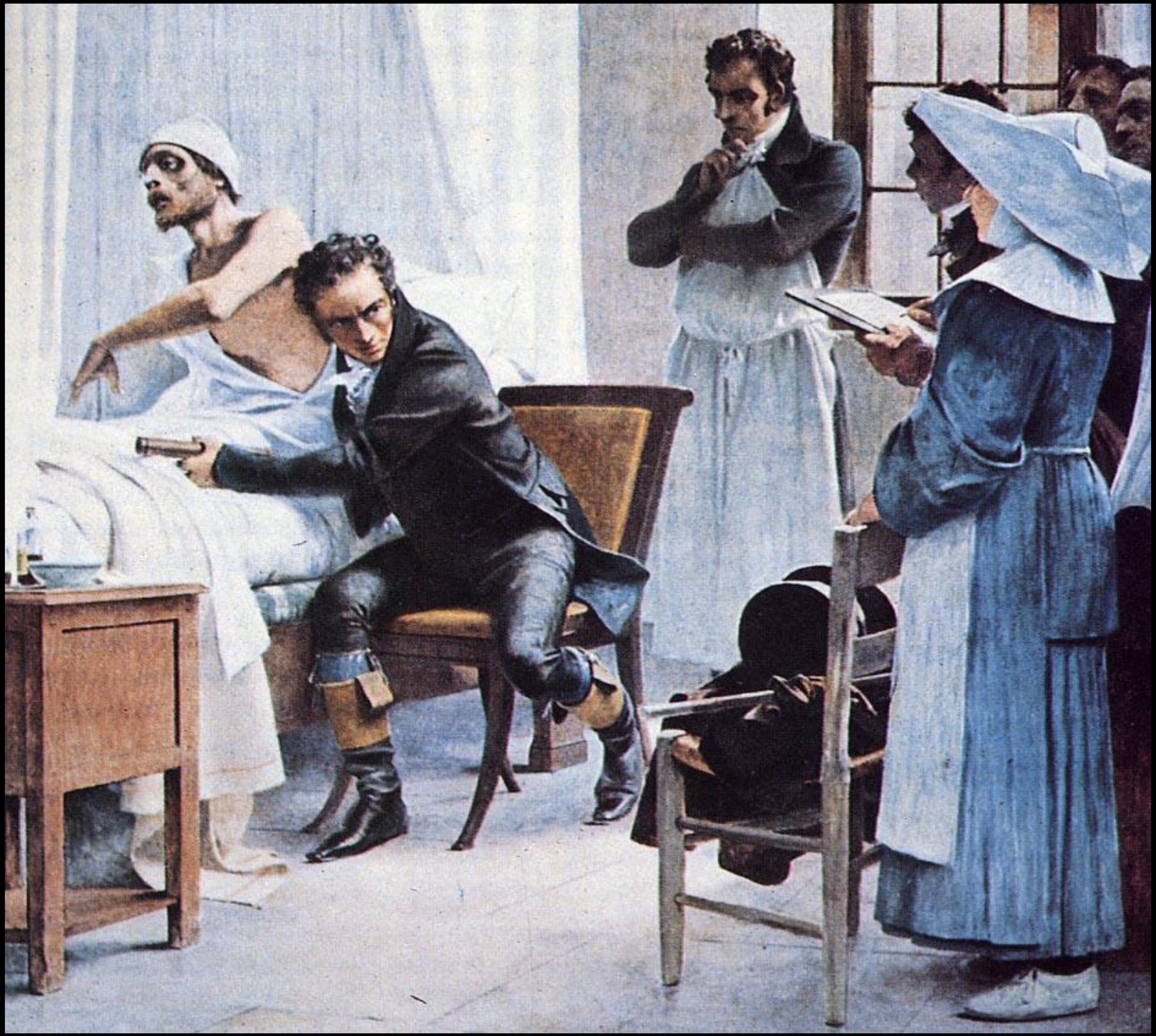
- Co-initiator and teacher

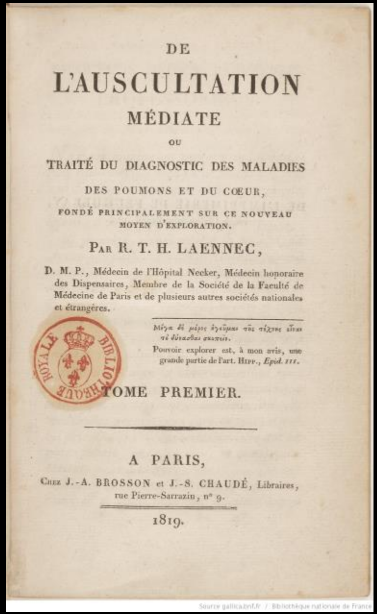
«Medecine, Technology and Society»

- Leader Study group «Cuffless BP»

- Co-founder start-up

To see inside the body





DE

L'AUSCULTATION

MÉDIATE

OU

TRAITÉ DU DIAGNOSTIC DES MALADIES

DES POUMONS ET DU CŒUR,

FONDÉ PRINCIPALEMENT SUR CE NOUVEAU MOYEN D'EXPLORATION.

Par R. T. H. LAENNEC,

D. M. P., Médecin de l'Hôpital Necker, Médecin honoraire des Dispensaires, Membre de la Société de la Faculté de Médecine de Paris et de plusieurs autres sociétés nationales et étrangères.

Μέγα δὲ μέρος ἡγεῦμαι τῆς τέχνης εἶναι τὸ δύνασθαι σκοπεῖν.

Pouvoir explorer est, à mon avis, une grande partie de l'art. Hipp., *Epid. III.*

BIBLIOTHEQUE ROYALE

TOME PREMIER.

A PARIS,

Chez J.-A. BROSSON et J.-S. CHAUDÉ, Libraires, rue Pierre-Sarrazin, n° 9.

1819.

Source gallica.bnf.fr / Bibliothèque nationale de France

« Laennec à l'hôpital Necker ausculte un phtisique devant ses élèves » (1816)

The best monitoring ever ?

Did you know...?

The National Institute of Medicine found that anesthesiologists are the ONLY physician specialty to significantly reduce patient mortality.

There were *50 times fewer* deaths due to physician anesthesiologist efforts.
1 in 5,000 to 1 in approximately 250,000.[1]

[1] Kohn, Corrigan and Donaldson.
To Err is Human. Institute of Medicine, 1999.

California Society of ANESTHESIOLOGISTS
Physicians for Vital Times

#patientsafety

1905

2017

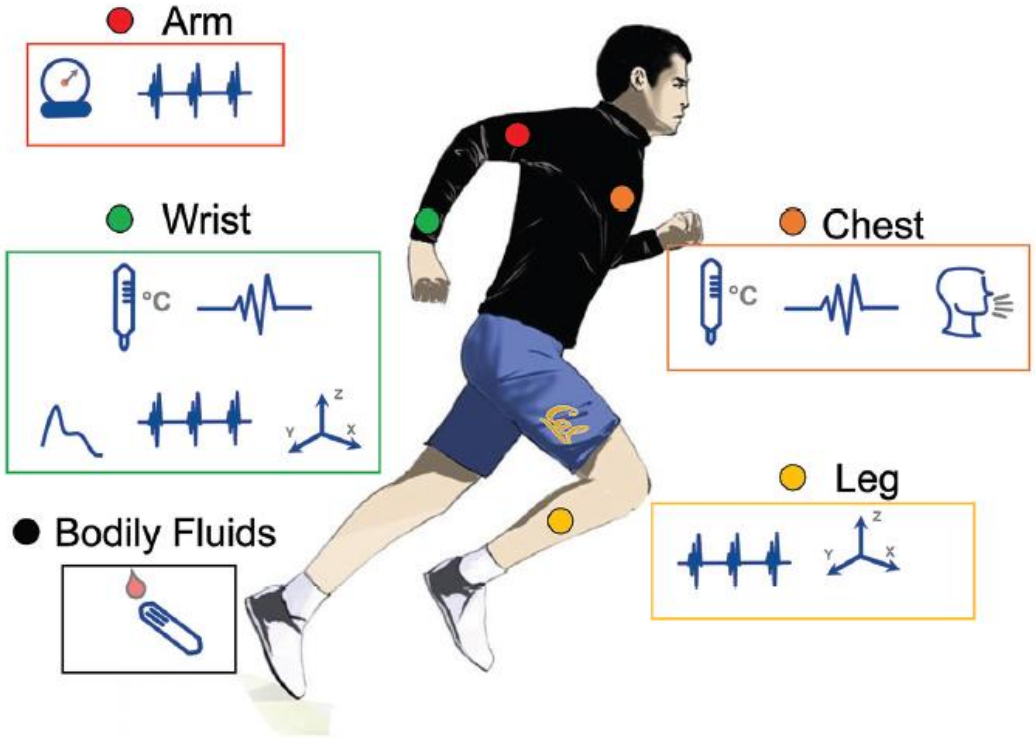
2000

Height: 381mm
Width: 381mm
Depth: 435mm
Weight: 15,800g
Price: £1,500
CPU: 500MHz
RAM: 128MB
Display: 1024 x 768
Storage: 30GB

2010

Height: 115.2mm
Width: 58.6mm
Depth: 9.3mm
Weight: 137g
Price: £599
CPU: 1GHz
RAM: 512MB
Display: 960x640
Storage: 32GB


Apollo 11 was landed on
the moon using a computer
that had 1,300 times less
processing power than iPhone 5s
factECards.com



°C 2.1. Temperature

2.2. Heart Rate

2.3. Respiration Rate

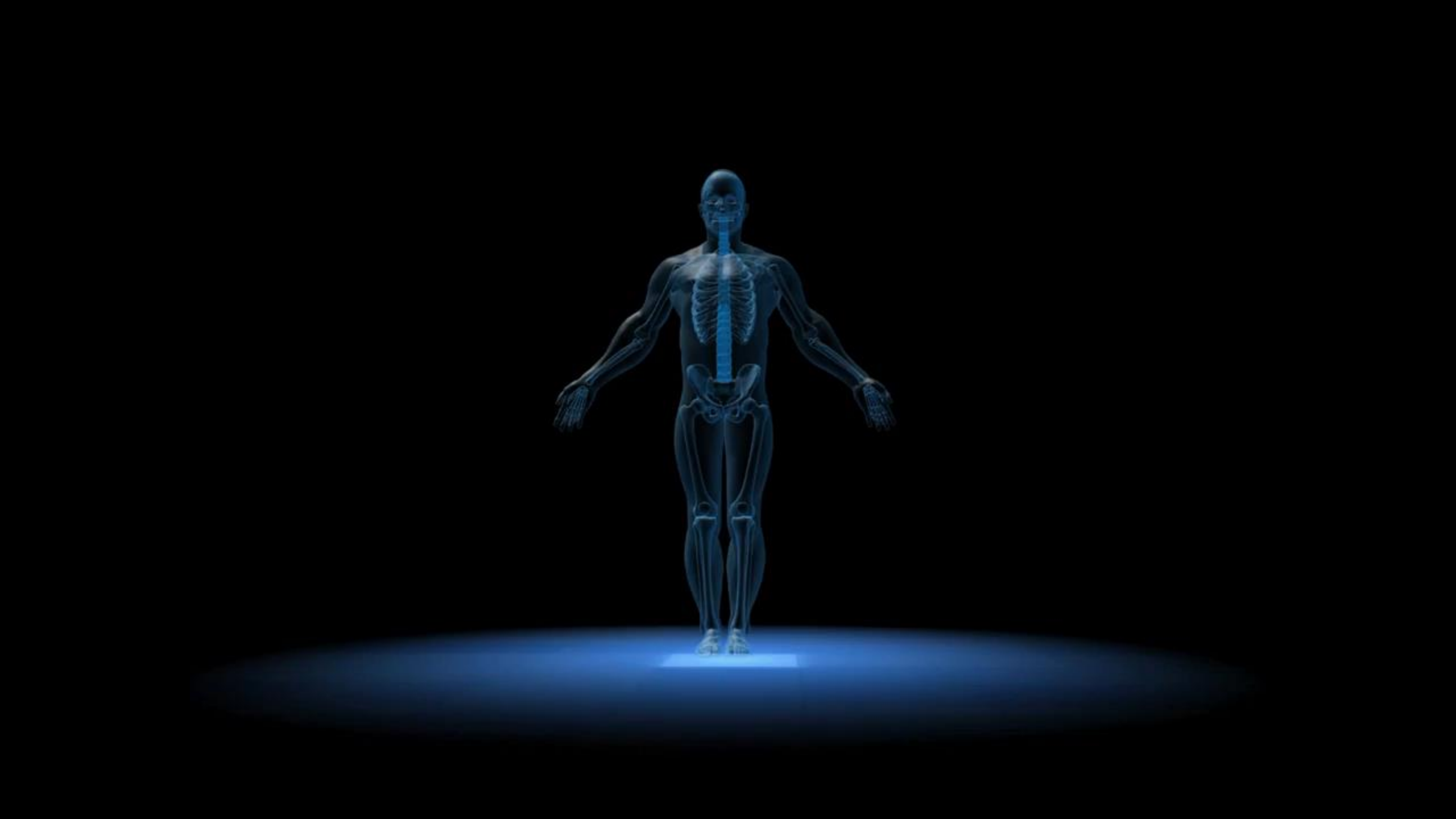
2.4. Blood Pressure

2.5. Pulse Oxygenation

2.6. Blood Glucose

Bioelectronic

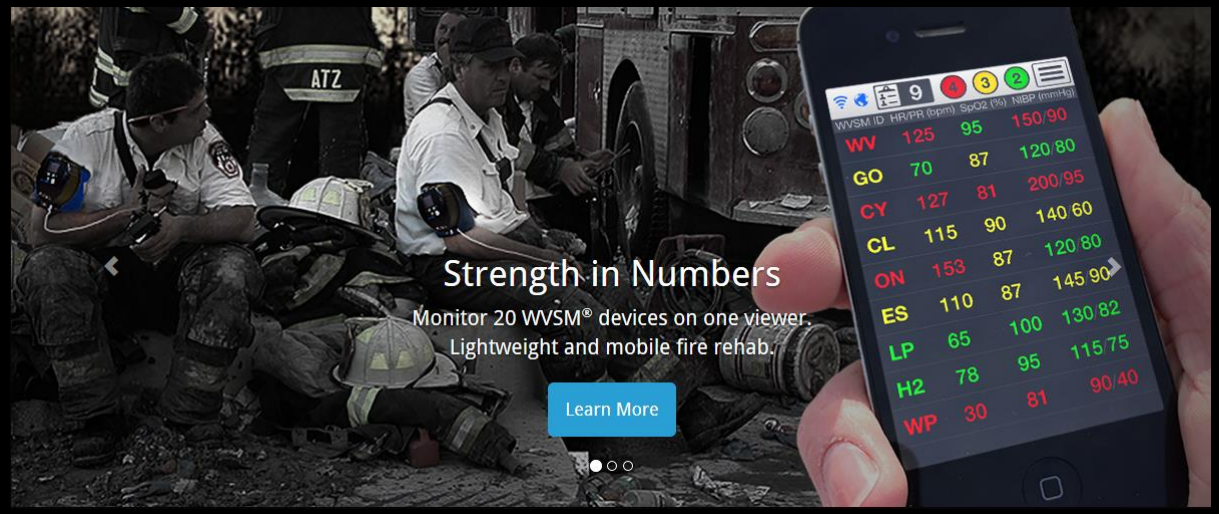
Z
Y
X
Motion

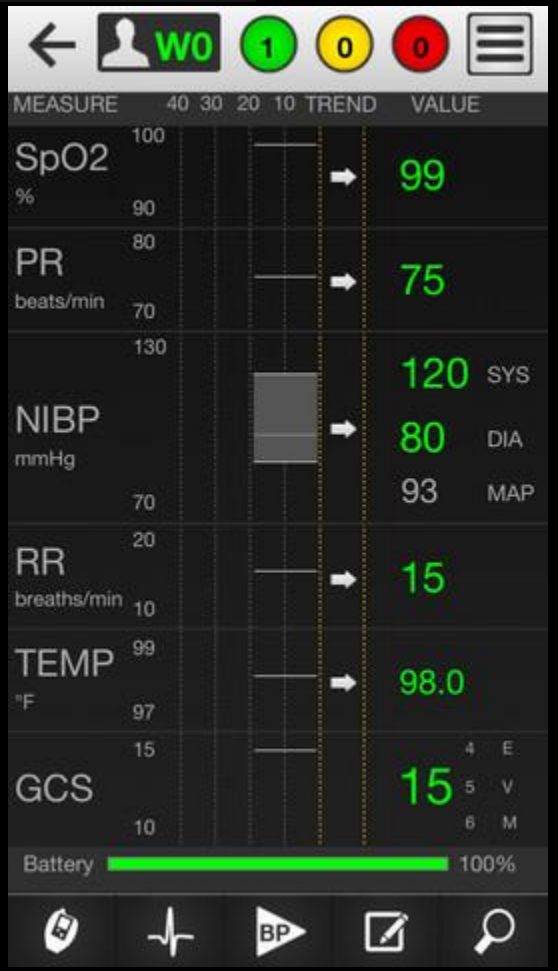


iOS App

The WVSM® iOS app is FDA cleared and available for use with iPhone, iPod and iPad.

Available on the App Store





Conf Proc IEEE Eng Med Biol Soc. 2013;2013:6498-501. doi: 10.1109/EMBC.2013.6611043.

Protective jacket enabling decision support for workers in cold climate.

Seeberg TM, Vardoy AS, Austad HO, Wiggen O, Stenersen HS, Liverud AE, Storholmen TC, Faerevik H.

NOTICE

NO CELL PHONE WHILE IN TRIAGE AND PATIENT ROOMS

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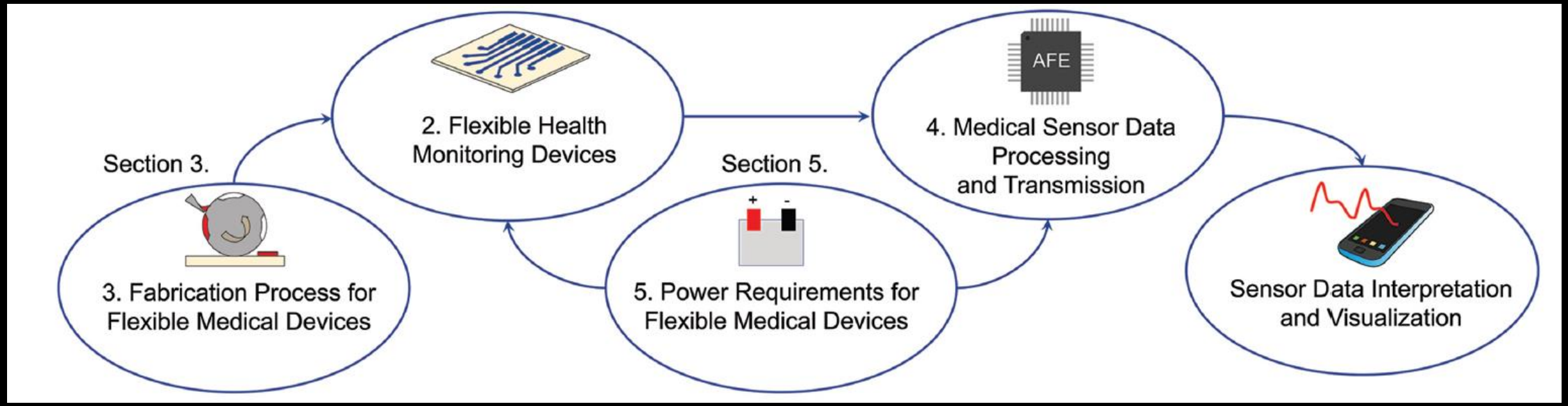
Wireless monitoring in the OR



Medical Devices in a wireless world

- Regulatory bodies

  FDA (Food and Drug Administration)

  FCC (Federal Communications Commission)

For medical devices,

FDA requirements are considered primary

FCC requirements considered supplementary

What are the concerns ?

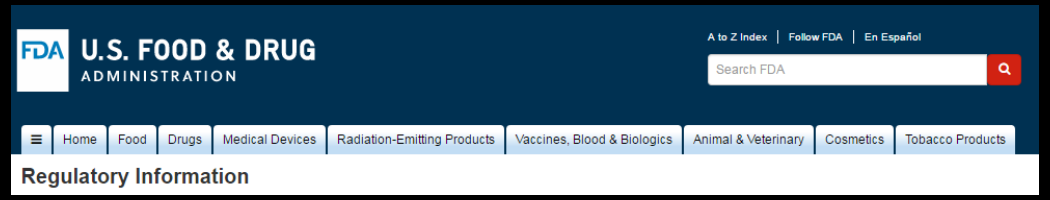
- Security breach of patient information

  HIPPA act (Health Insurance Portability and Acountability)

- Malfunction

- Interference

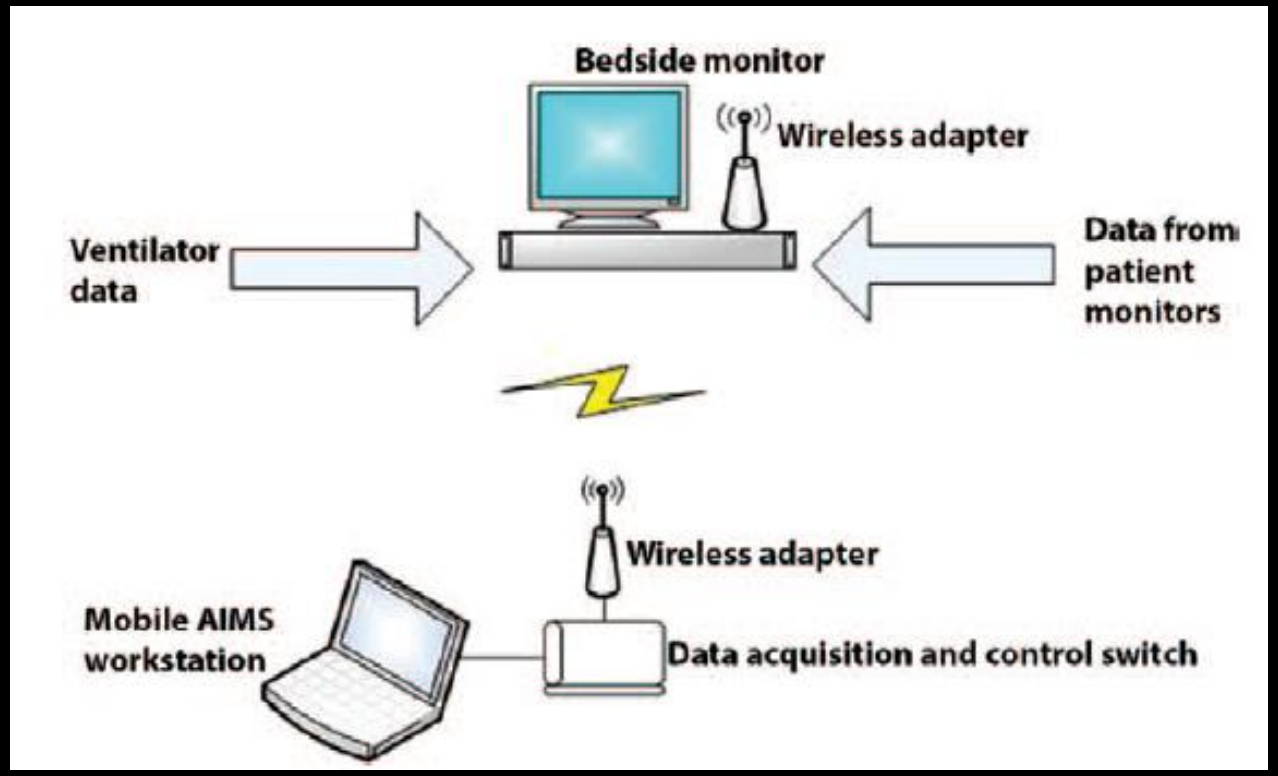
- Cost



A Technical Evaluation of Wireless Connectivity from Patient Monitors to an Anesthesia Information Management System During Intensive Care Unit Surgery

Allan F. Simpao, MD,*† Jorge A. Galvez, MD,*† W. Randall England, BA,† Elicia C. Wartman, BA,† James H. Scott, CNA,† Michael M. Hamid, Sr., CE,† Mohamed A. Rehman, MD,*† and Richard H. Epstein, MD‡

Anesth Analg 2016;122:425–9



Society for Technology in Anesthesia
Section Editor: Maxime Cannesson
TECHNICAL COMMUNICATION

A Technical Evaluation of Wireless Connectivity from Patient Monitors to an Anesthesia Information Management System During Intensive Care Unit Surgery

Table 3. Wireless Intensive Care Unit Data Gap Analysis Results

Case no.	Procedure	Case duration (min)	Number of consecutive data gaps	Total data gap duration (min:s)
1	Diaphragmatic hernia repair	146	0	0
2	Abdominal wound closure	69	0	0
3	Thoracotomy and pneumonectomy	157	0	0
4	Diaphragmatic hernia repair	104	0	0
5	Diaphragmatic hernia repair	97	0	0
6	Diaphragmatic hernia repair	141	1	1:15
7	Diaphragmatic hernia repair	156	0	0
8	Diaphragmatic hernia repair	156	0	0
9	Diaphragmatic hernia repair	160	0	0
10	Diaphragmatic hernia repair	229	0	0
11	Diaphragmatic hernia repair	170	0	0
12	Laparotomy, colostomy, bowel resection	212	1	0:15
13	Diaphragmatic hernia repair	101	0	0
14	Diaphragmatic hernia repair	134	0	0
15	Diaphragmatic hernia repair	144	0	0
16	Diaphragmatic hernia repair	144	1	38:00
17	Diaphragmatic hernia repair	150	0	0
18	Diaphragmatic hernia repair	98	0	0
19	Diaphragmatic hernia repair	77	0	0
20	Diaphragmatic hernia repair	131	0	0
21	Re-exploration of abdomen	54	0	0
22	Diaphragmatic hernia repair	136	0	0
23	Diaphragmatic hernia repair	74	0	0
24	Diaphragmatic hernia repair	86	0	0
25	Central line placement	82	0	0
26	Thoracotomy, lung biopsy	51	0	0
27	Diaphragmatic hernia repair	177	0	0
28	Diaphragmatic hernia repair	80	0	0
29	Diaphragmatic hernia repair	100	0	0
30	Diaphragmatic hernia repair	122	0	0

EDITORIAL

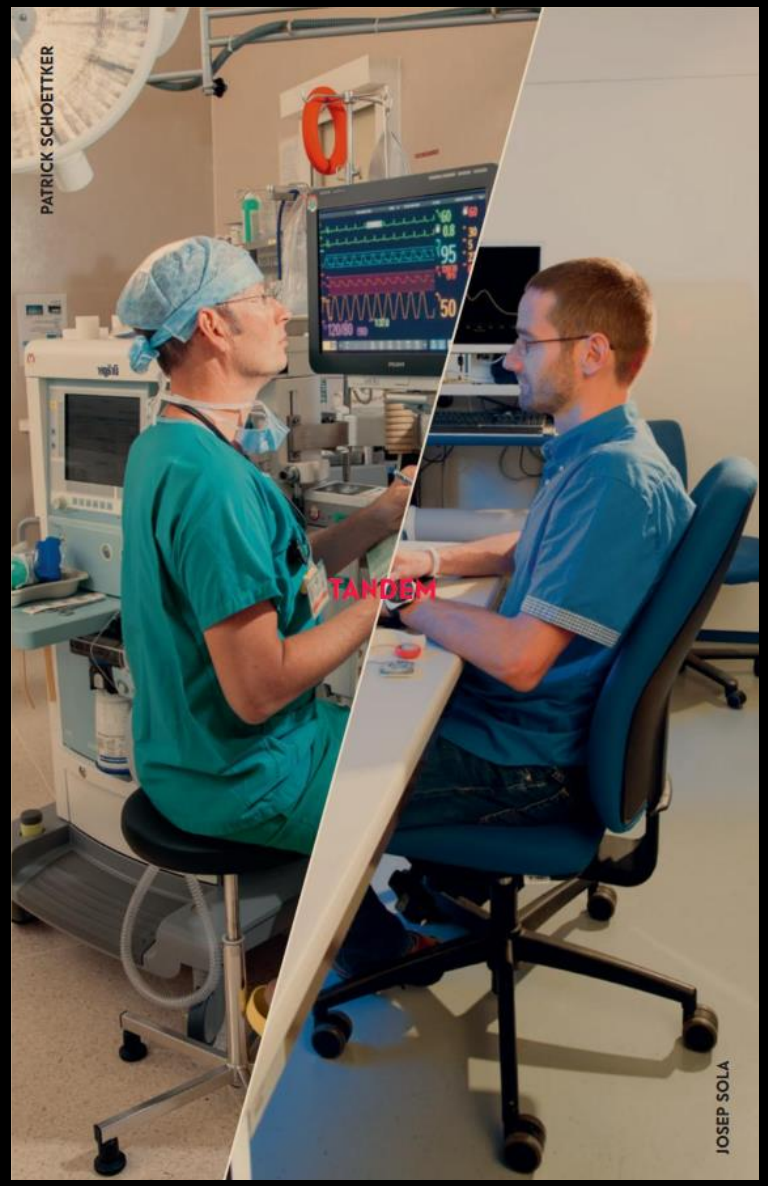
Is Wireless the Future of Monitoring?

Ira Hofer, MD,* and Maxime Cannesson, MD, PhD†

February 2016 • Volume 122 • Number 2

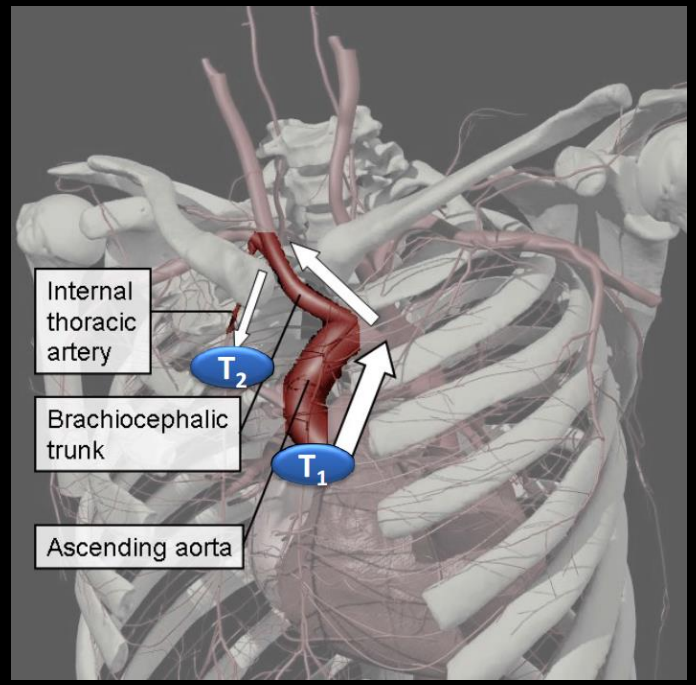
We must lobby our hospitals to explore new technology. We must conduct research to better understand the risks and benefits of wireless monitoring. If such studies demonstrate clear benefits to our patients, then we must work with our hospitals to make wireless monitoring a clinical reality.

No solutions



No problems

Study Number	2015/01
Study Title	**Comparison of an optical method to continuously measure blood pressure against an invasive arterial catheter**



Study Number	2015/01
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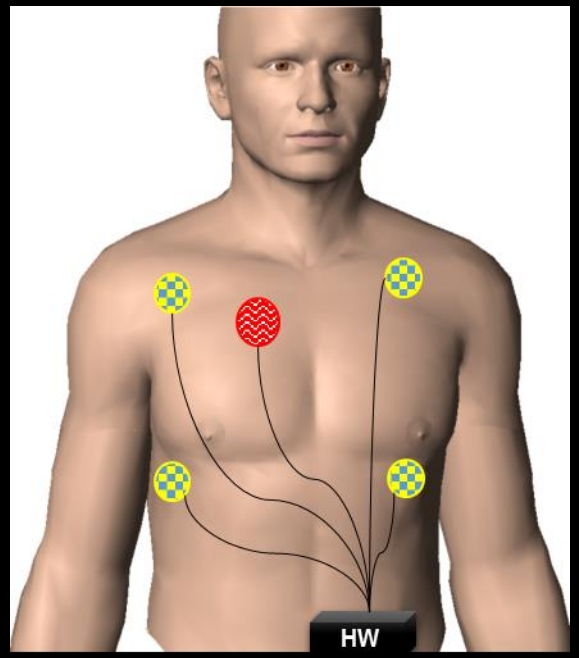

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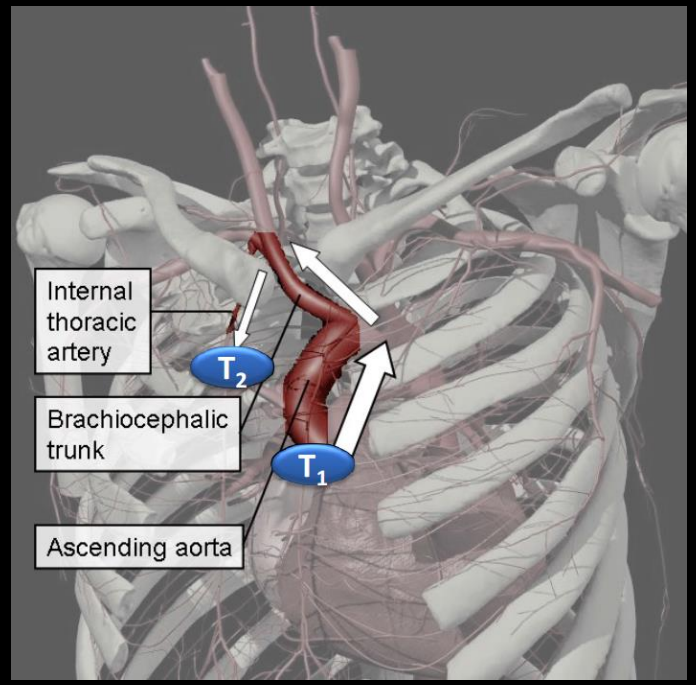
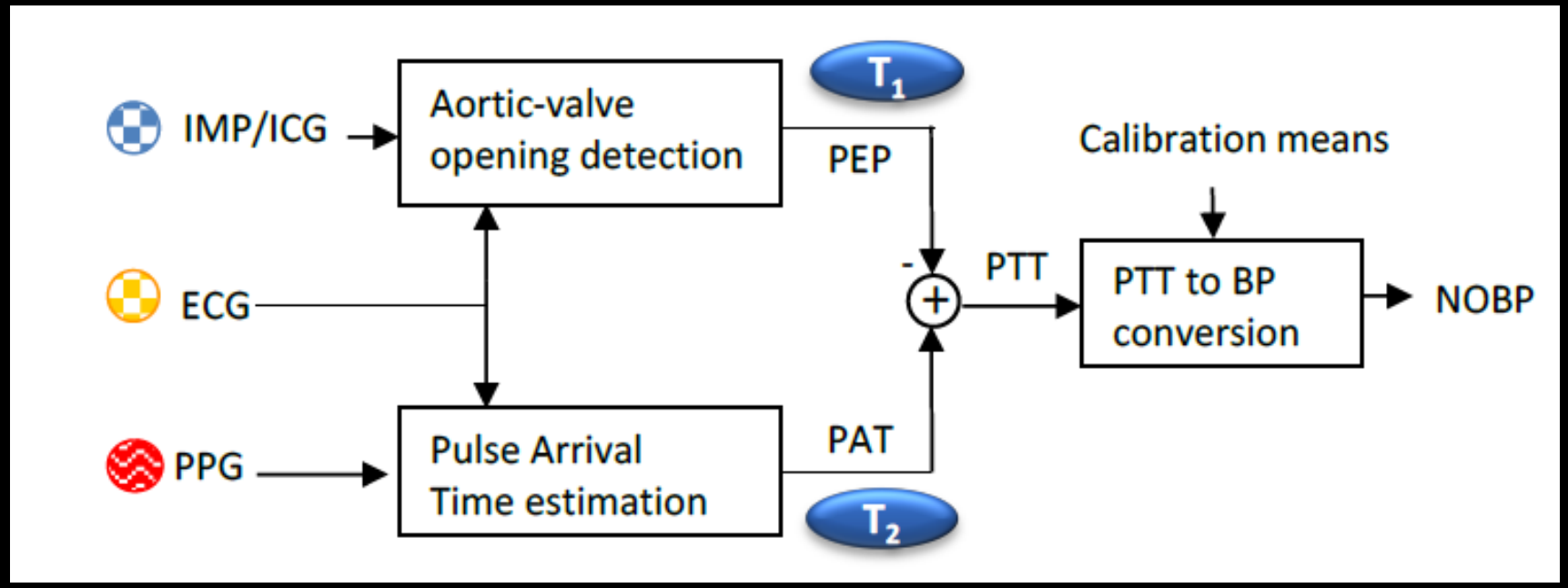


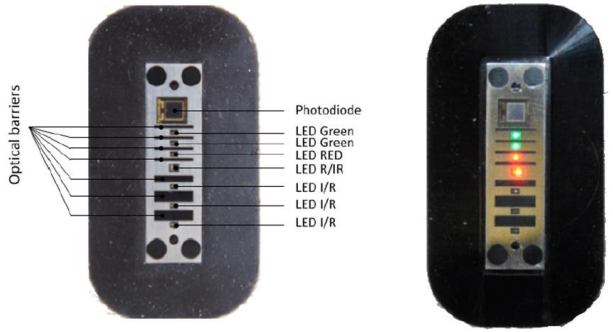


ICG: Impedance-Cardiogram
ECG: Electro-Cardiogram
PPG: Photo-Plethysmogram

PEP: Pre-Ejection Period (T_1)
PAT: Pulse Arrival Time (T_2)
PTT: Pulse Transit Time

BP: Blood Pressure

Collaboration



re 3: Interface with patient: the optical probe, with switched on and switched off

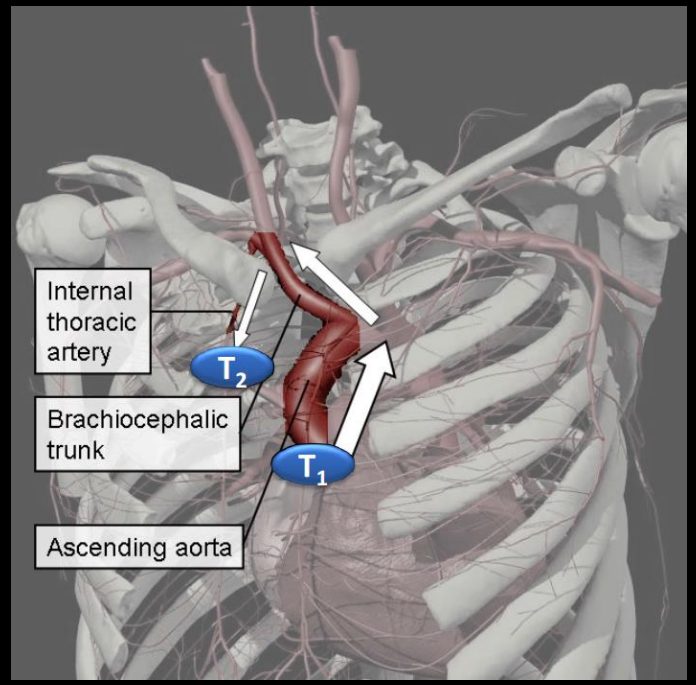
CSEM: research platforms

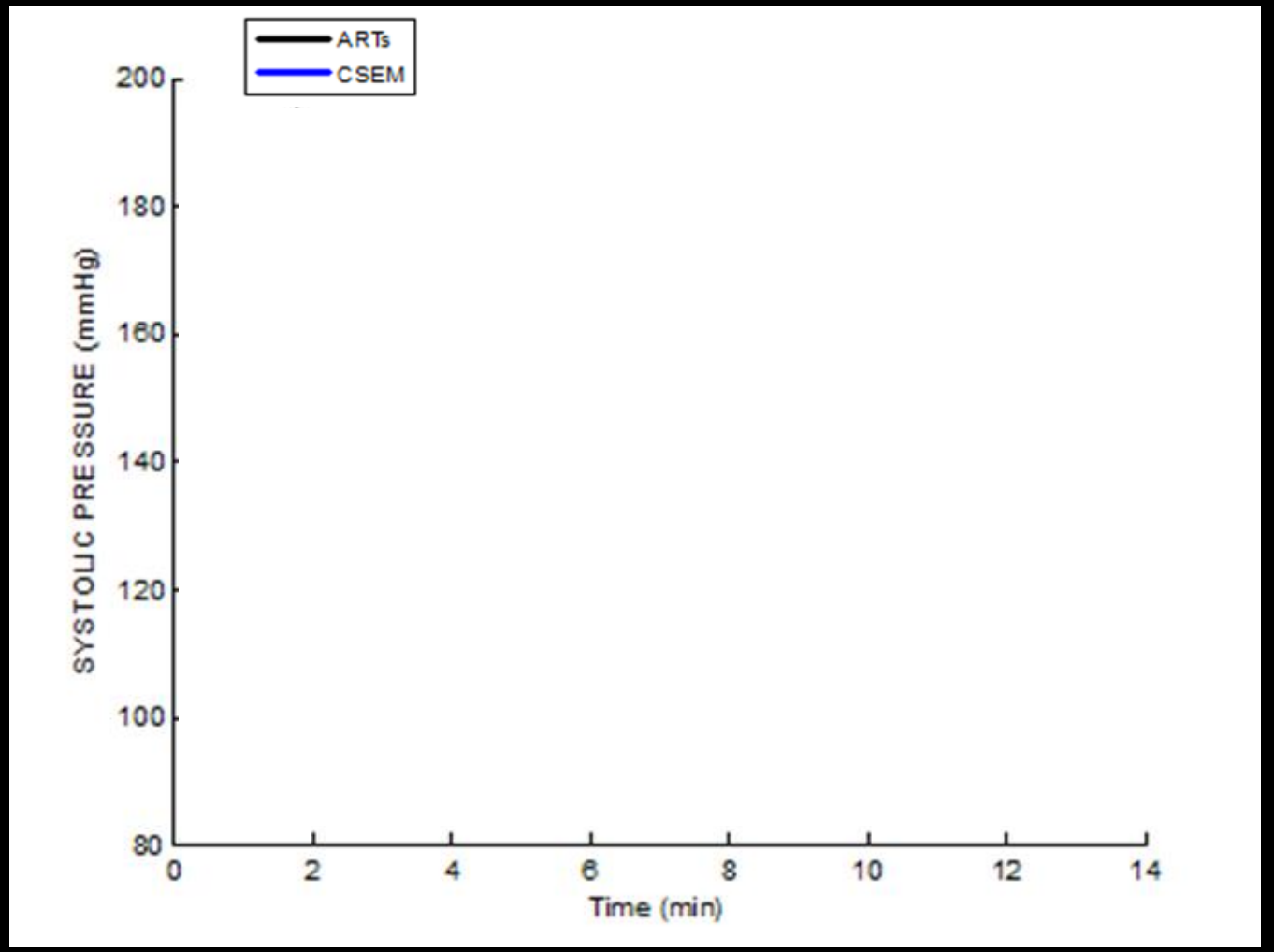
CHUV: clinical studies

csem

CHUV

Study Number	2015/01
Study Title	**Comparison of an optical method to continuously measure blood pressure against an invasive arterial catheter**





Josep Solà*, Martin Proença, Fabian Braun, Nicolas Pierrel, Yan Degiorgis, Christophe Verjus, Mathieu Lemay, Mattia Bertschi and Patrick Schoettker

Continuous non-invasive monitoring of blood pressure in the operating room: a cuffless optical technology at the fingertip

Current Directions in Biomedical Engineering 2016; 2(1): 267–271

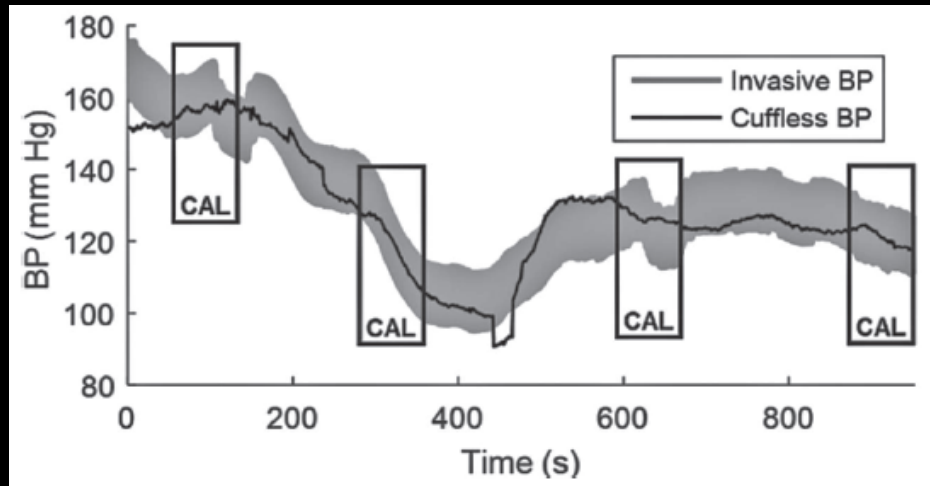


Figure 3: Performance of the cuffless blood pressure estimation technique on a particular study patient during induction of anesthesia. Each data point corresponds a patient's heart beat. Temporal evolution of invasive systolic blood pressure is displayed as ±8 mm Hg range (shaded in grey).

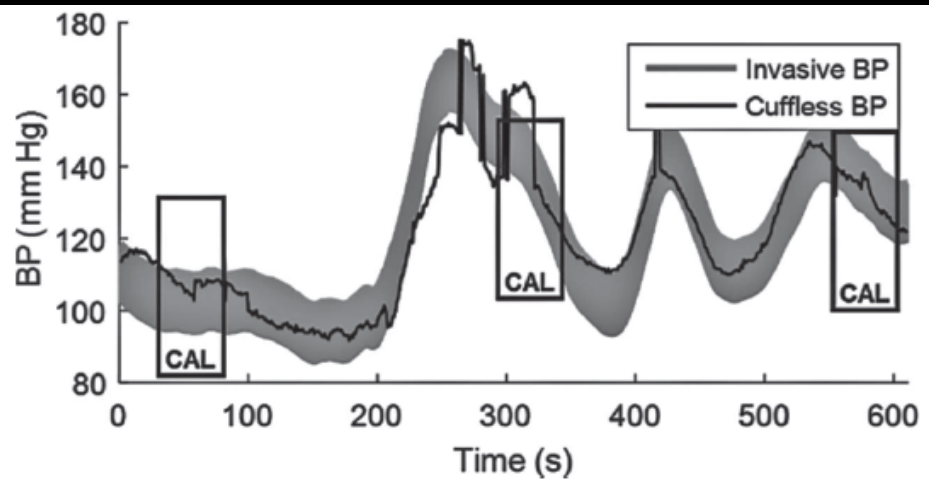


Figure 4: Performance of the cuffless blood pressure estimation technique on a particular study patient during induction of anesthesia. Each data point corresponds a patient's heart beat. Temporal evolution of invasive systolic blood pressure is displayed as ±8 mm Hg range (shaded in grey).

Performance of Systolic Blood Pressure estimation from radial Pulse Arrival Time (PAT) in anesthetized patients

J. Solà[1], A. Vybornova[1], F. Braun[1], M. Proença[1], R. Delgado-Gonzalo[1], D. Ferrario[1], C. Verjus[1], M. Bertschi[1], N. Pierrel[2] and P. Schoettker[2]

[1] Systems Division, CSEM, Neuchâtel, Switzerland
[2] Anesthesia Department, CHUV, Lausanne, Switzerland

Abstract— **The performance of estimating Systolic Blood Pressure (SBP) in anesthetized patients via Pulse Arrival time (PAT) techniques was studied with respect to the minimum required time in between two recalibration procedures.**

Materials: a clinical trial [NCT02651558] involving 14 patients was conducted measuring PAT from an ECG and an arterial line inserted into the radial artery.

Methods: comparison of BP estimates from PAT measurements against invasive BP values was performed in terms of mean error and standard deviation of the error (AAMI/ANSI/ISO 81060-2), cumulative percentage of readings falling within 5, 10 and 15 mmHg (BHS criteria), and MAD - Mean Absolute Difference (IEEE Std 1708). Two calibration strategies were explored, involving time between recalibration periods ranging from 10 seconds to 8 minutes.

Results: assuming an affine calibration function between PAT and SBP, different slope (Mean Slope: -1.45, CI: -1.64 to -1.27 mmHg/ms) and offset values (Mean Offset: 575, CI: 517 to 633 mmHg) were found in between patients. In addition, given a patient, affine calibration functions at different anesthesia phases also showed to be variable. When assessing agreement in terms of existing international standards it was found that PAT-based SBP estimates complied with requirements when time between two calibrations was smaller than 60 seconds.

Conclusions: the use of anesthetic agents compromises the implementation of PAT-based techniques to estimate SBP.

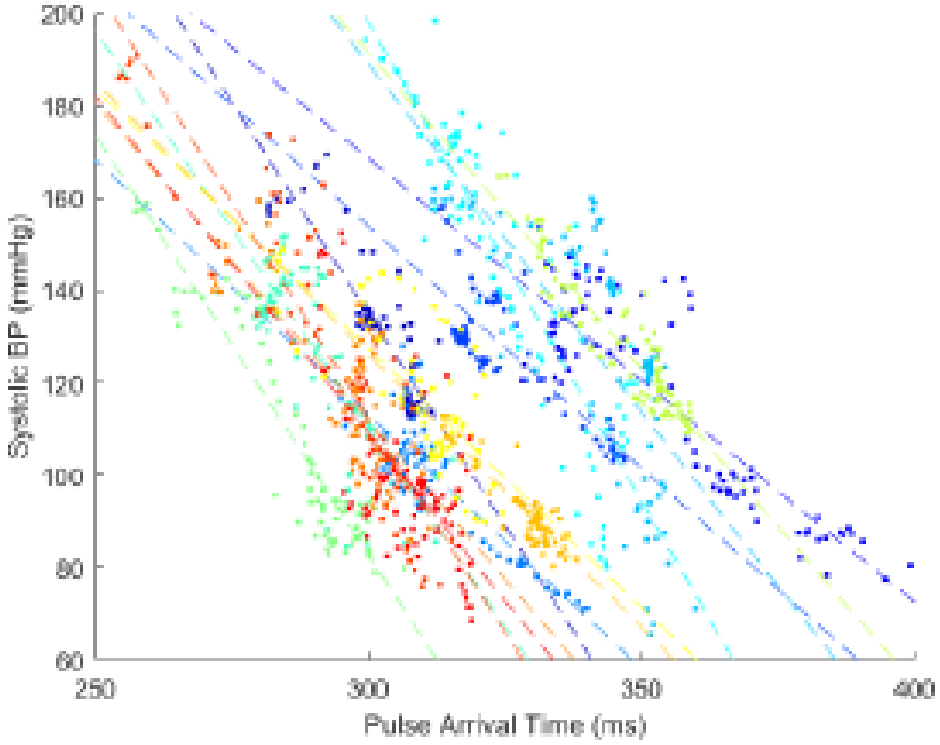
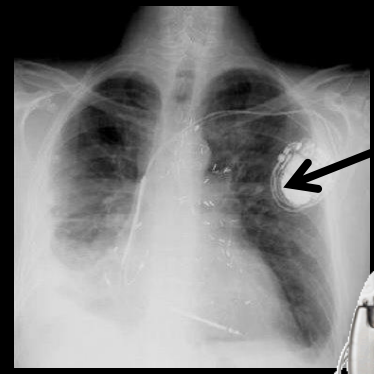


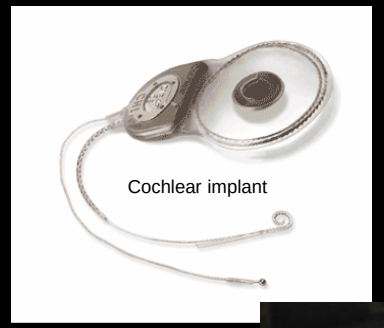
Fig. 1 Correlation plots between PAT and Systolic BP for the 14 recruited subjects: colored dots depict measurement points, and dashed lines depict their associated affine calibration functions.

Implantable / wearable Medical Devices

- Existing
  - Glucose sensor and insulin pump
  - Pacemaker/defibrillator
  - Neurostimulator
  - Cochlear implant
- Emerging
  - Ingestible “smart-pills”
  - Drug delivery
  - Sub-cutaneous biosensor
  - Brain implant
  - Deep cardiac implant
  - Smart Orthodontia
  - Glaucoma sensors and ocular implants
- Futuristic
  - Body 2.0 - Continuous Monitoring of the Human Body
  - Bio-reactors
  - Cyber-human Interfaces

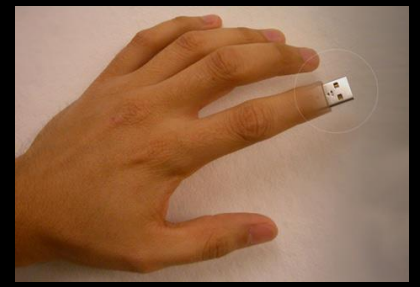


Neurostimulator



Cochlear implant

Subcutaneous biosensor – EPFL-Nanotera



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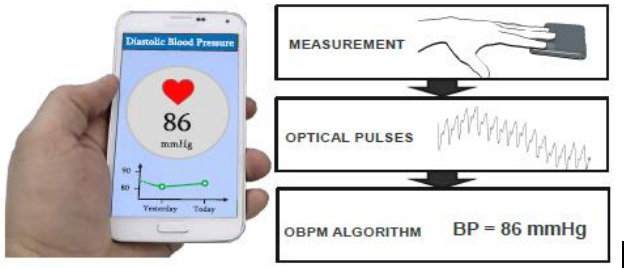
Blood Pressure Monitoring Using a Smartphone Camera: Performance of the OBPM Technology

J. Sola[1] , M. Proença[1], P. Schoettker[2] , F. Braun[1], C. Verjus[1] , M. Bertschi[1] , C. Verjus[1] , E. Jones[2], T. Kunz[2]

1 CSEM S.A. - Centre Suisse d'Electronique et de Microtechnique, Neuchâtel, Switzerland – **Josep.Sola@csem.ch**

2 Biospectal Inc., Lausanne, Switzerland

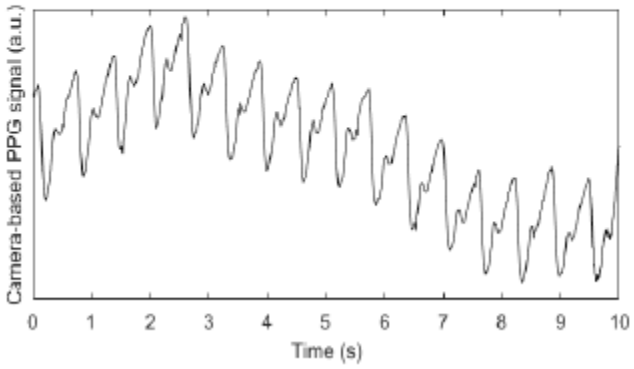


MATERIALS AND METHODS

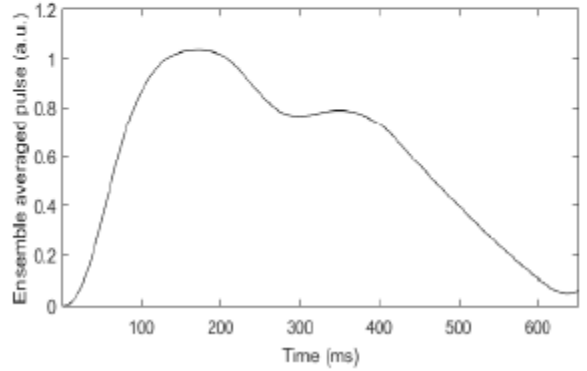
We implemented a measurement campaign on 35 healthy volunteers that performed physical exercises. The volunteers were requested to apply their right forefinger on top of the camera of a commercial smartphone while video sequences were acquired.

The video sequences were then processed by the OBPM algorithms, and the predicted blood pressure values were compared to reference oscillometric blood pressure readings.

Example of 10 seconds of a fingertip PPG signal obtained from a video sequence recorded on a healthy volunteer.



Example of ensemble-averaged pulse calculated from 10 seconds of PPG signal



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RESULTS AND CONCLUSIONS

The overall performance over the entire cohort of 35 healthy volunteers is provided in the following table. Two calibration strategies were tested:

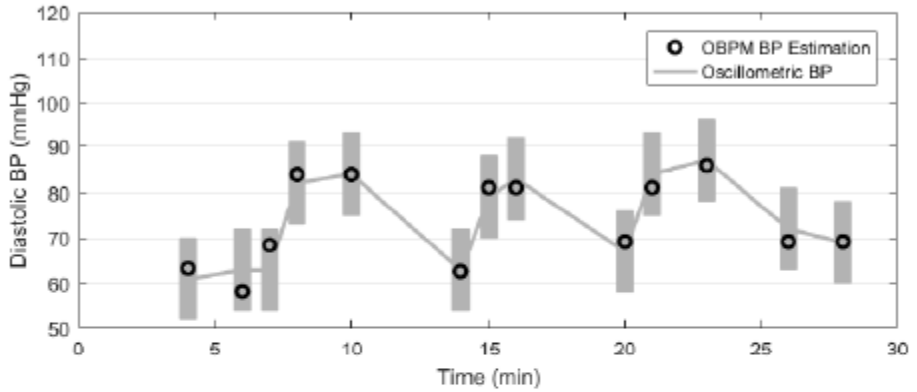
Initial calibration: the output of the OBPM algorithm was shifted in offset using the first reference oscillometric diastolic blood pressure measurement.

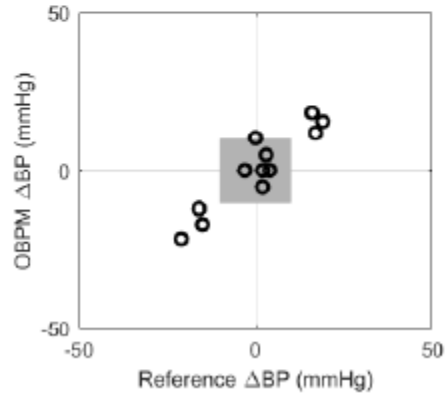
Full calibration: the output of the OBPM algorithm was shifted and scaled to best match the reference measurements

OBPM™ Algorithm		*Initial Cal.*	*Full Cal.*
ISO81060-2 performances	Mean Error	4.0 mmHg	0.32 mmHg
	Stdev Error	8.22 mmHg	7.02 mmHg

This study demonstrates that the estimation of blood pressure by means of video sequences recorded by a commercial smartphone camera are feasible by means of the OBPM library of algorithms.

Example of performance of the OBPM algorithm on a healthy volunteer





Absolute BP performances
Mean error: 0 mmHg (<±5 mmHg)
Stdev error: 2.8 mmHg (<8 mmHg)

BP changes performances
Perror : 3.9 mmHg (<10 mmHg)
Concordance Rate : 85.7 % (>90%)


Adulte
17 Fév 10:48
Profils
Ecran Dynamique
60
0.1
95
120/70
(91)
120/80 (90)
37.0
Patients du Moniteur et du MMS différents

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we care, we respect, we deliver

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MAJOR INCIDENT - UPDATE

MAJOR INCIDENT – APPOINTMENTS CANCELLED

A virus infected our electronic systems on Sunday October 30 and we have taken the decision, following expert advice, to shut down the majority of our systems so we can isolate and destroy it.

All planned operations, outpatient appointments and diagnostic procedures have been cancelled for Wednesday November 2 with a small number of exceptions as follows:

- Audiology
- Physiological measurements
- Antenatal
- Community and therapy
- Chemotherapy
- Paediatrics

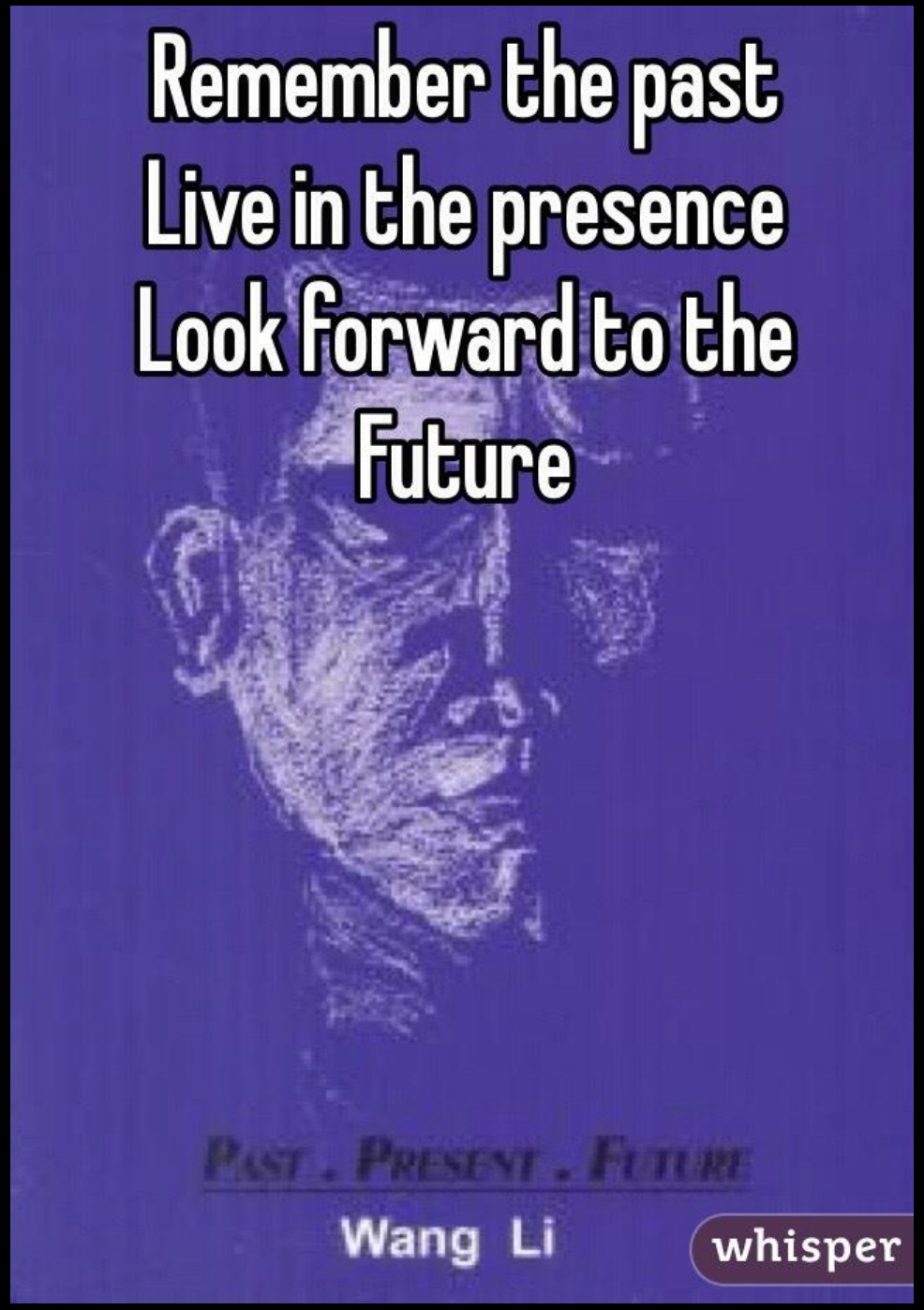
Big Data, for better or worse?

- 90 percent of the world's data has been generated in just the last two years
- New sensors and devices surrounding and embedding themselves into our everyday lives
- *Our bodies are generating a continuous data stream 24 hours a day, and venture capitalists are jumping on this trend"* Maneesh Juneja healthcare futurist

SINTEF

SINTEF is the largest independent research organisation in Scandinavia

Michael O'Reilly MD is an anesthesiologist who lists teaching gigs at University of Michigan and University of California at Irvine on his LinkedIn



Thank you very much ☺

patrick.schoettker@chuv.ch