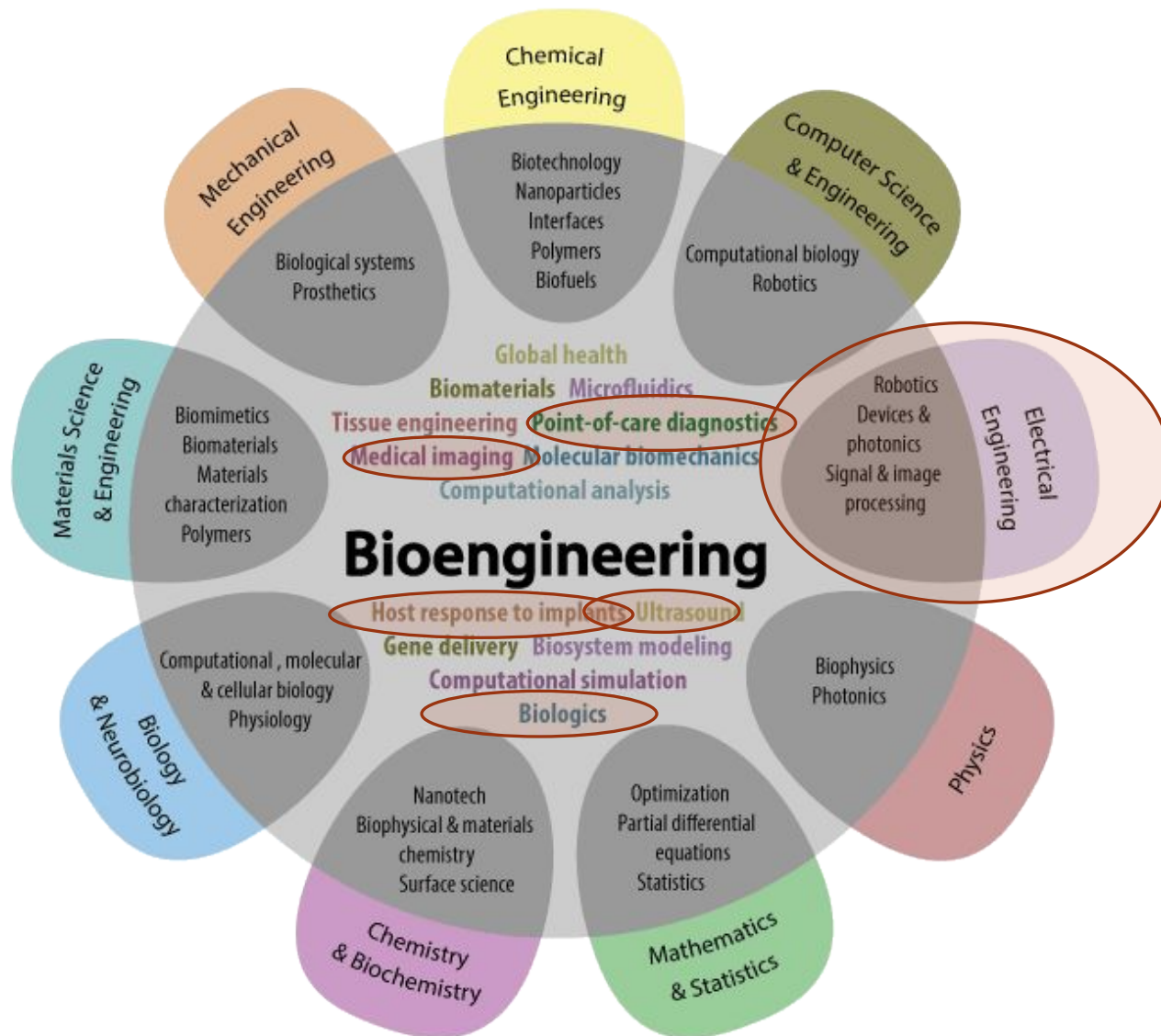


# Biomedicínské inženýrství v klinické praxi

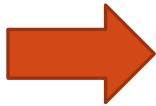
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ING. JANA HRUŠKOVÁ

# Chápání pojmu biomedicínské inženýrství



# Chápání pojmu biomedicínské inženýrství dle WHO



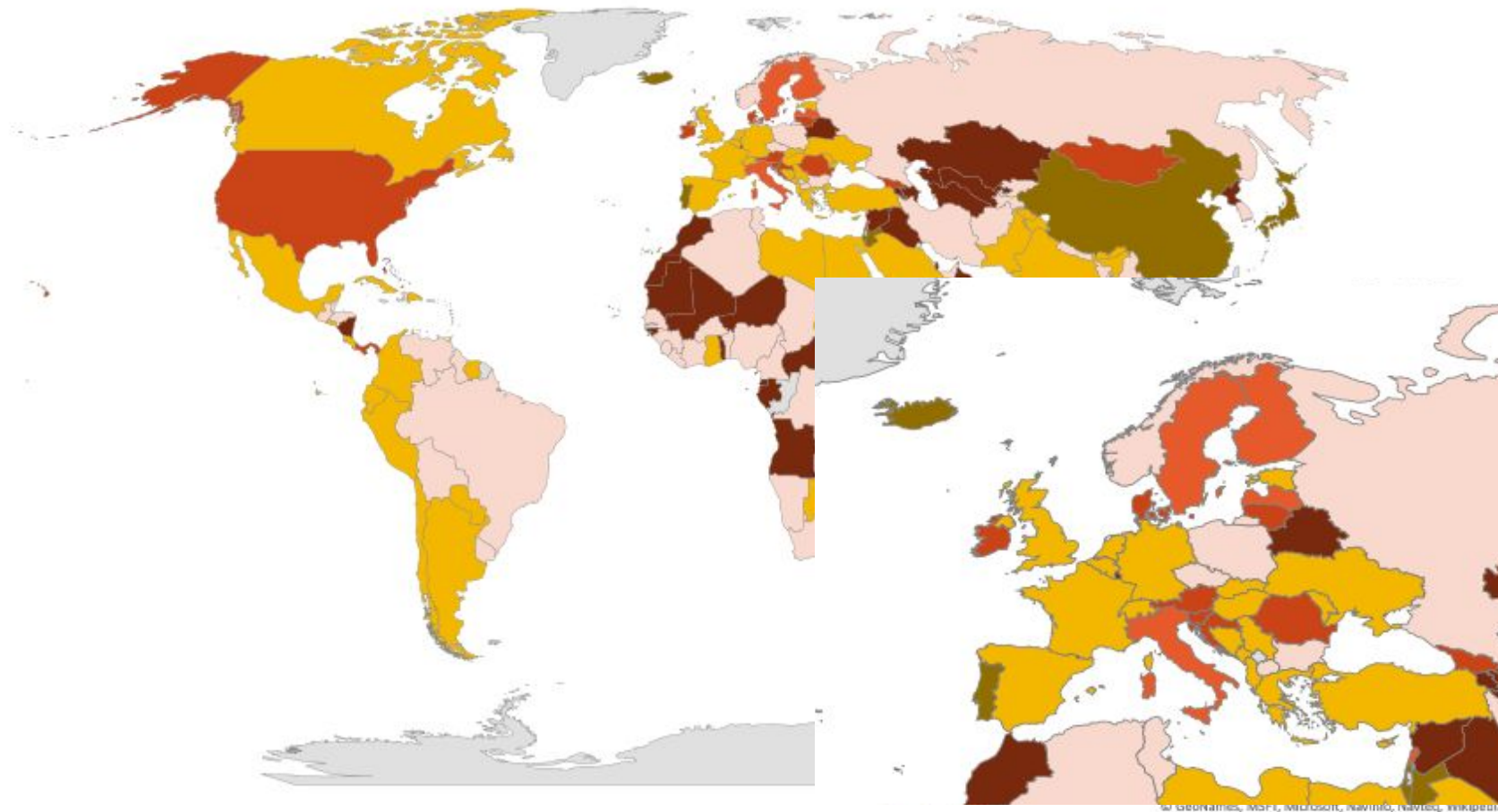
**Biomedical engineering (BME):** Medical and BME integrates physical, mathematical and life sciences with engineering principles for the study of biology, medicine and health systems and for the application of technology to improve health and quality of life. It creates knowledge from molecular to organ systems levels, develops materials, devices, systems, information approaches, technology management and methods for assessment and evaluation of technology, for the prevention, diagnosis and treatment of disease, for health-care delivery and for patient care and rehabilitation. (24)

**Clinical engineer:** In some countries, this defines the biomedical engineer that works in clinical settings. The American College of Clinical Engineering defines a clinical engineer as, "a professional who supports and advances patient care by applying engineering and managerial skills to health care technology" (25) The Association for the Advancement of Medical Instrumentation describes a clinical engineer as, "a professional who brings to health-care facilities a level of education, experience, and accomplishment which will enable him to responsibly, effectively, and safely manage and interface with medical devices, instruments, and systems and the user thereof during patient care..." (26)

**Biomedical engineering technician/technologist (BMET):** Front-line practitioners dedicated to the daily maintenance and repair of medical equipment in hospitals, meeting a specified minimum level of expertise. BMETs who work exclusively on complex laboratory and radiological equipment may become certified in their specialism, without needing to meet the more general professional engineering requirements. The difference between a technician and a technologist relates to the level and number of years of training. Normally technicians train for two years, technologists for three years, but this can differ per country.

# Geografické údaje dle WHO – množství biomediálních inženýrů na 10 000 lidí

0-0,05 0,06-0,5 0,6-1 1,0-1,5 >1,5 no data



# Geographic breakdown by date of publication = Most of the biomedical engineering researchers in 10 000 people

| PUBLISH STATISTICS | Year     | WHO region | Country     | Biomedical engineers density (per 10 000 population) | Biomedical engineers density (per 10 000 population) | Biomedical engineers density (per 10 000 population) (comment)    | Number of biomedical engineers | Number of biomedical engineers |
|--------------------|----------|------------|-------------|--|--|---|--------------------------------|--------------------------------|
| Published          | (string) | (string)   | (string)    | (numeric)  | (numeric)  | (comment)   | (string)                       | (numeric)                      |
| Published          | 2017     | Europe     | Belarus     | No data  |  |   | No data                        |                                |
| Published          | 2017     | Europe     | Belgium     | 0.44   | 0.44   | Reported number of biomedical engineers by country.               | 500                            | 500                            |
| Published          | 2017     | Europe     | Bosnian     | 0.11   | 0.11   | Reported number of biomedical engineers by country.               | 50                             | 50                             |
| Published          | 2017     | Europe     | Bulgaria    | 0.05   | 0.05   | Reported number of biomedical engineers by country.               | 15                             | 15                             |
| Published          | 2017     | Europe     | Croatia     | 0.6  | 0.6  | Reported number of biomedical engineers by country.               | 250                            | 250                            |
| Published          | 2017     | Europe     | Cyprus      | 0.13   | 0.13   | Reported number of biomedical engineers by country.               | 15                             | 15                             |
| Published          | 2017     | Europe     | Czechia     | <0.05  |  | Presence of biomedical engineers but not available specific data. | 21                             | 1                              |
| Published          | 2017     | Europe     | Denmark     | 0.79   | 0.79   | Reported number of biomedical engineers by country.               | 600                            | 600                            |
| Published          | 2017     | Europe     | Estonia     | 0.46   | 0.46   | Reported number of biomedical engineers by country.               | 60                             | 60                             |
| Published          | 2017     | Europe     | Finland     | 1.55   | 1.55   | Reported number of biomedical engineers by country.               | 850                            | 850                            |
| Published          | 2017     | Europe     | France      | 0.09   | 0.09   | Reported number of biomedical engineers by country.               | 600                            | 600                            |
| Published          | 2017     | Europe     | Georgia     | 0.67   | 0.67   | Reported number of biomedical engineers by country.               | 250                            | 250                            |
| Published          | 2017     | Europe     | Germany     | 0.25   | 0.25   | Reported number of biomedical engineers by country.               | 2050                           | 2050                           |
| Published          | 2017     | Europe     | Greece      | 0.28   | 0.28   | Reported number of biomedical engineers by country.               | 300                            | 300                            |
| Published          | 2017     | Europe     | Hungary     | 0.41   | 0.41   | Reported number of biomedical engineers by country.               | 400                            | 400                            |
| Published          | 2017     | Europe     | Iceland     | 1.68   | 1.68   | Reported number of biomedical engineers by country.               | 56                             | 56                             |
| Published          | 2017     | Europe     | Ireland     | 0.69   | 0.69   | Reported number of biomedical engineers by country.               | 110                            | 110                            |
| Published          | 2017     | Europe     | Israel      | 2.34   | 2.34   | Reported number of biomedical engineers by country.               | 2000                           | 2000                           |
| Published          | 2017     | Europe     | Italy       | 1.1  | 1.1  | Reported number of biomedical engineers by country.               | 8177                           | 8177                           |
| Published          | 2017     | Europe     | Kazakhstan  | No data  |  |   | No data                        |                                |
| Published          | 2017     | Europe     | Kyrgyzstan  | <0.05  |  | Reported number of biomedical engineers by country.               | 8                              | 8                              |
| Published          | 2017     | Europe     | Latvia      | 1.12   | 1.12   | Reported number of biomedical engineers by country.               | 220                            | 220                            |
| Published          | 2017     | Europe     | Lithuania   | 0.87   | 0.87   | Reported number of biomedical engineers by country.               | 250                            | 250                            |
| Published          | 2017     | Europe     | Luxembourg  | No data  |  |   | No data                        |                                |
| Published          | 2017     | Europe     | Malta       | No data  |  |   | No data                        |                                |
| Published          | 2017     | Europe     | Monaco      | No data  |  |   | No data                        |                                |
| Published          | 2017     | Europe     | Netherlands | 0.29   | 0.29   | Reported number of biomedical engineers by country.               | 500                            | 500                            |
| Published          | 2017     | Europe     | Norway      | <0.05  |  | Presence of biomedical engineers but not available specific data. | 21                             | 1                              |
| Published          | 2017     | Europe     | Poland      | <0.05  |  | Reported number of biomedical engineers by country.               | 163                            | 163                            |
| Published          | 2017     | Europe     | Portugal    | 2  | 2  | Reported number of biomedical engineers by country.               | 2060                           | 2060                           |
| Published          | 2017     | Europe     | Republic    | 0.25   | 0.25   | Reported number of biomedical engineers by country.               | 90                             | 90                             |



USA



VELKÁ BRITÁNIE



ČESKÁ REPUBLIKA

BAKALÁŘSKÝ OBOR

Biomedicínský technik  
Sonografista  
Elektrofyzilogický technik  
Vaskulární technik  
ICD/pacemaker technik  
Neurologicko diagnostický technik  
Technik v Invazivní kardiologii

Biomedicínský technik

3 roky

MAGISTERSKÝ OBOR

Biomedicínské inženýrství

Biomedicínské inženýrství

Biomedicínské  
inženýrství  
akreditované

Biomedicínské  
inženýrství  
neakreditované

2 roky

SPECIALIZACE

Klinické inženýrství  
(CCE)

Klinické  
inženýrství  
(pod HCPC)

Klinický inženýr –  
Diagnostika\*

AKK

Klinický inženýr –Kardiologie\*  
Klinický inženýr – Chirurgie, intenzivní  
medicína\*  
Klinický inženýr – Radioterapie\*  
Klinický inženýr – Biosignály\*

2-4 roky

<https://www.indeed.com/> ; <http://www.carnegie-institute.edu/programs/cardiovascular-technologist/> ; \* zkrácené názvy

# Klinické obory

---

## Technická podpora



- Servis přístrojů
- Aplikační specialisté

## Výzkum



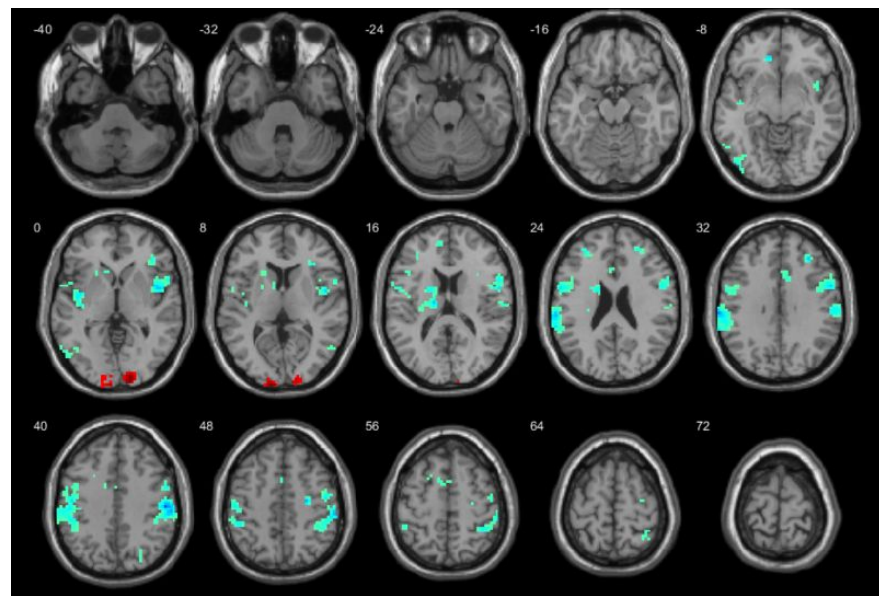
- Laboratorní technika
- Diagnostické přístroje
- Genetika
- Klinický i teoretický výzkum

## Diagnostická podpora



- Kardiologie
- Neurologie
- Oftalmologie
- Protetika

# MRI



„ Zařízení magnetické rezonance *Siemens MAGNETOM Prisma 3T* v hodnotě 55 mil. Kč. Vpravo snímky z funkční magnetické rezonance zobrazující oblasti mozku aktivované při snaze regulovat vlastní reakci (emoce) u sledování vizuálních podnětů s nechutným obsahem.“

(ve spolupráci s Ing. Veronikou Fabíkovou, operátorkou magnetické rezonance v **Laboratoři multimodálního a funkčního zobrazování** v oblasti aplikovaných neurověd, **CEITEC**)



# Elektrofyzologie

příprava  
pacienta

1



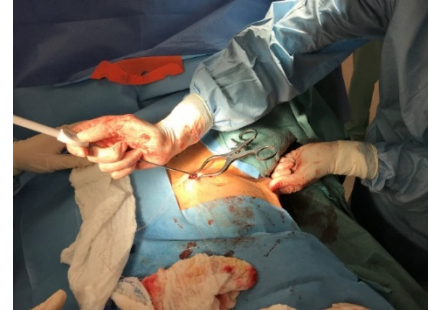
tvorba kapsy

2



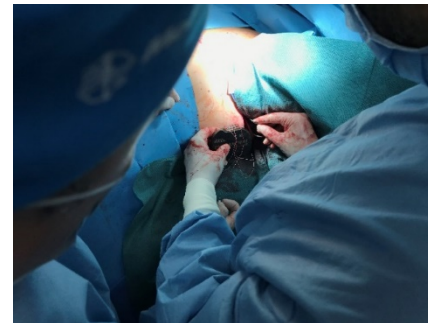
3

tunelizace



4

napojení ICD



„V sféře invazivní elektrofyzologie provádí bioinženýr přípravu pacienta a konečné testování. Cena přístroje dosahuje 400 000 Kč a denně se jich v různých verzích zaimplantuje přibližně 5.“

(ve spolupráci s Ing. Davidem Pospíšilem, předsedou pracovní skupiny **KardioTech** a technikem z **Interní kardiologické kliniky FN Brno**)

# Kardiologie

5

Test funkce po implantaci kardioverter-defibrilátoru (max. tepová frekvence ve videu 349/min., výboj 65 J)



navození  
tachyarytmie

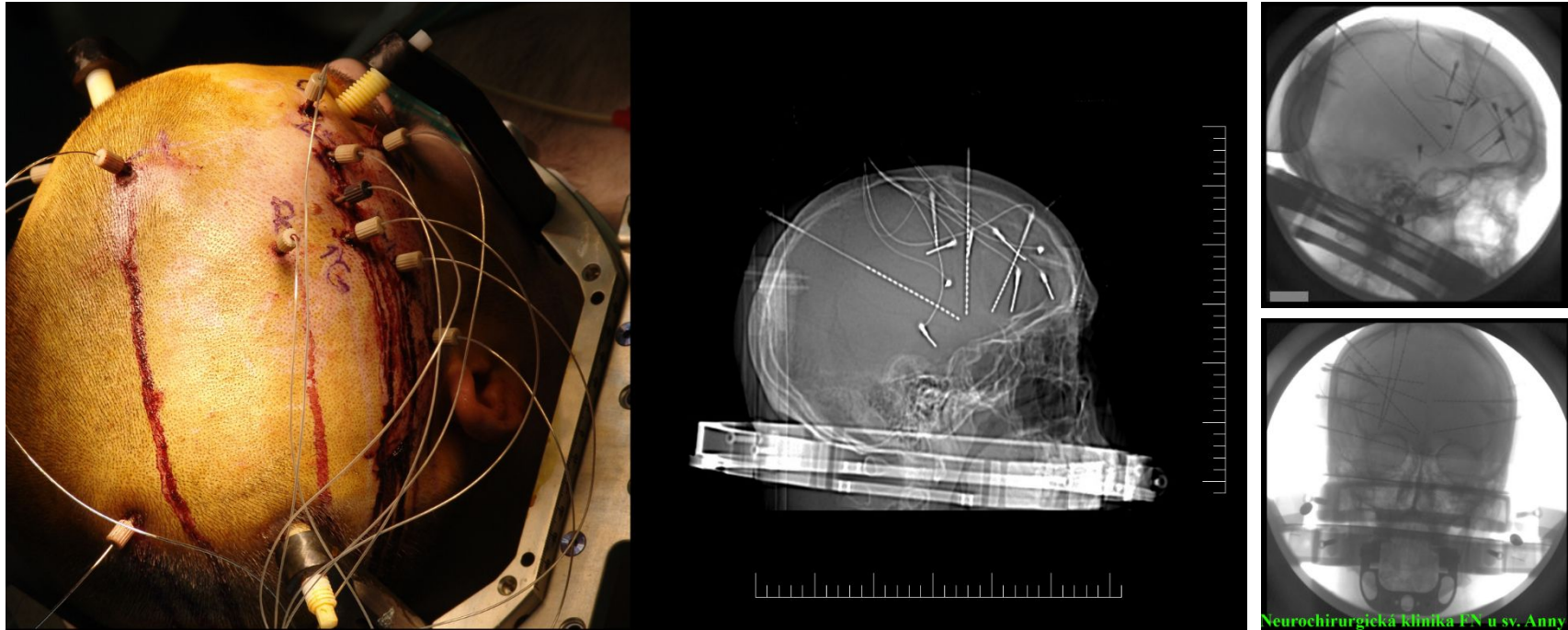
detekce  
patologie

nabíjen  
í

defibrilační výboj

terminace  
tachyarytmie

# Neurochirurgie



„ Invasivně zavedené intracerebrální elektrody s následnou RTG kontrolou pro monitoraci EEG a k zjištění epileptického ložiska.“

(ve spolupráci s Ing. Zdeňkem Strmiskou a Ing. Ivem Říhou z **Neurochirurgické kliniky FN u sv. Anny v Brně**)

# Spirometrické laboratoře

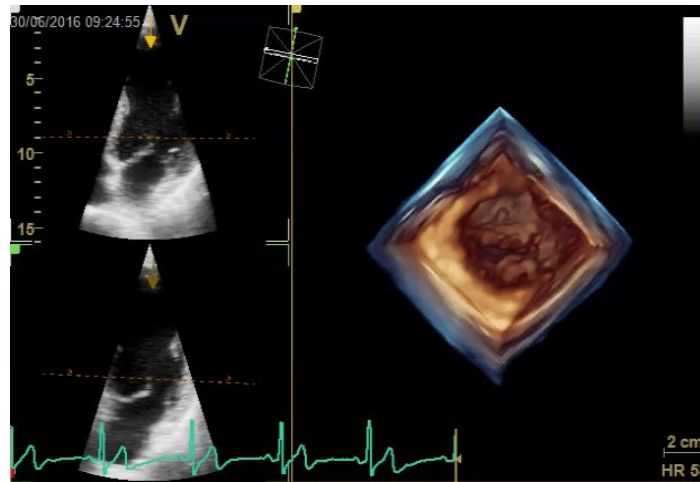
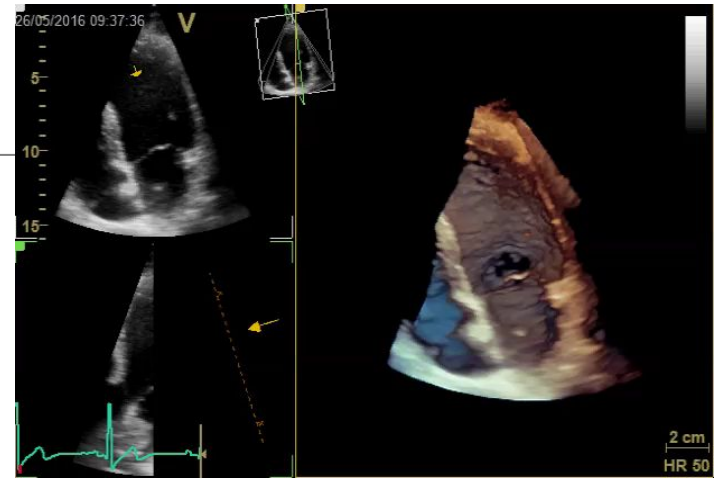
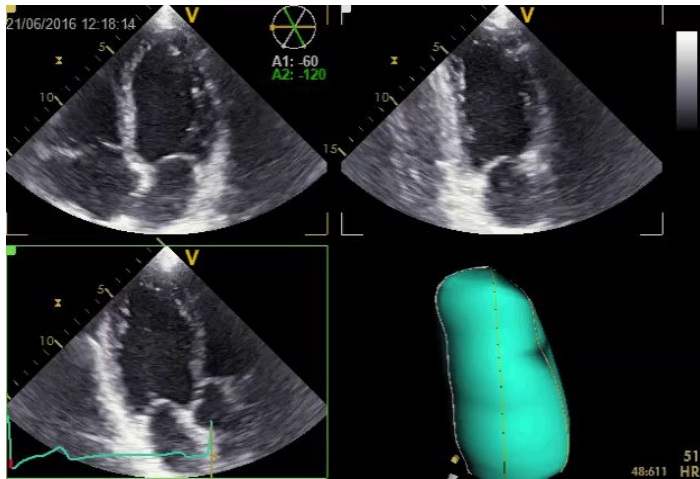
---



„Aktivní elektro-mechanický model plic pro účely simulace lidského dýchání a analýzu inhalovaných částic aerosolů.“

(ve spolupráci s Ing. Richardem Paštěkou, MSc., výzkumníkem v oblasti respiračních technologií z **Univerzity aplikovaných věd ve Vídni**)

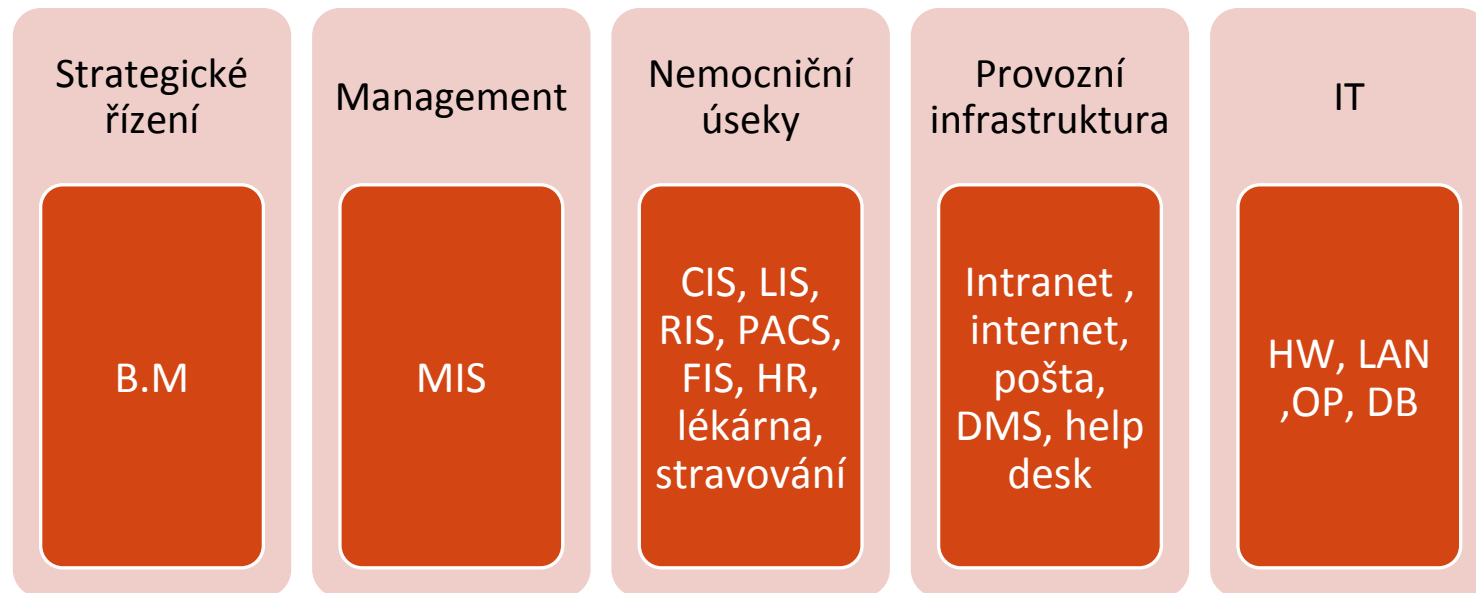
# Echokardiografie



# NIS (nemocniční informační systém)

---

- Soustava vzájemně provázaných informačních systémů
- Úloha: podpora podsystémů a jejich vzájemná komunikace. Dokumentace a řízení nemocničních procesů



# Data v NIS

Typy:

- Strukturovaná data
- Nestrukturovaná data

**Přehled hospitalizací za období**

Oddělení: CHIRURGIE  
Lékař: MUDr. BILINA LADISLAV I 501 - 342004  
Zdr. po: 111 - VŠEOBECNÁ ZDRAVOTNÍ POJIŠTČ  
Skup. pac.: ZA VSECHNY

| Jméno           | Rod číslo / Datum | Typ | Kód | Počet / Množ. | Body  | Materiál |
|-----------------|-------------------|-----|-----|---------------|-------|----------|
| BILINA LADISLAV |                   |     |     | 4497,23       | 25956 | 22883,38 |
| pacientů :      |                   |     |     | 34            |       |          |
| hospitalizací : |                   |     |     | 34            |       |          |
| lůžkodenně :    |                   |     |     | 87            |       |          |

**NOVÁ VÁCLAVA**  
326262123  
11.07.2004 - 04.07.2004

| Typ     | Kód   | Body  |
|---------|-------|-------|
| KAT     | K43.0 | 4     |
| DIG     | I95.9 | 195.9 |
| DIG     | J39.9 | 139.9 |
| VVK     | 51021 |       |
| VVK Op. | 51513 |       |
| ZJM1    | 66020 |       |
| OP      | 00302 |       |
| KAT     | 3     | 3     |
| ZJM1    | 66020 |       |
| JIP     | 00358 |       |
| KAT     | 2     | 2     |
| ZJM1    | 66020 |       |
| JIP     | 00302 |       |
| VVK     | 51022 |       |
|         | C56.4 |       |
|         | M60.9 |       |

**NOVÁ MARIE**  
515614758  
11.06.2004 - 02.07.2004

| Typ | Kód   | Body |
|-----|-------|------|
| DIG | C56.4 |      |
|     | M60.9 |      |

**POLAK BOHEMIL (261201921)**  
201 Všeobecná zdravotní péči  
Národní zdravotní ústav  
Nový ústředí  
05.12.2016 08:10 - 05.12.2016 09:15  
Vyřadit anaer dne 30.11.2016 11:35  
Změnit anaer dne 30.11.2016 11:35

# Strukturovaná data

Formulářová kategorizace dat.

+ Rychlá kategorizace a vyhledávání

+ standardizace dat umožňující kvantitativní analýzy

- omezené možnosti formátu

The screenshot displays the 'The Archive Navigator' software interface. The main window is titled 'The Archive Navigator' and contains two primary sections: 'Patient Card' and 'Visit Card'.  
The 'Patient Card' section includes a header with a patient icon, navigation buttons (back, forward, search), a 'Sort by ID' checkbox, and a red circle highlighting a set of icons (add, delete, print). Below this are input fields for 'Name' (with 'Last' label), 'ID' (containing '1234567890'), 'Gender' (a dropdown menu set to 'Male'), and 'Birth' (containing '5/21/66').  
The 'Visit Card' section features a magnifying glass icon, navigation buttons, and a 'Date:' label. It contains input fields for 'Height (in): 0.', 'Weight (lb): 0.', and 'Age 0'. A 'Smoke' label is also visible at the bottom left of this section.



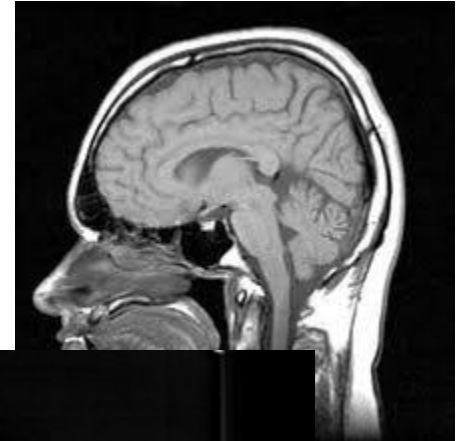
# Nestrukturovaná data

Data vytvořená nedatabázovými aplikacemi:

- Čistý text
- Web
- Video
- Grafiky
- Obrázky

+ Množství informací

- Různé nároky na formáty,
- - Nutnost zajistit data storage i odpovídající počítače pro čtení těchto dat
- Omezená možnost kvalitativní analýzy dat



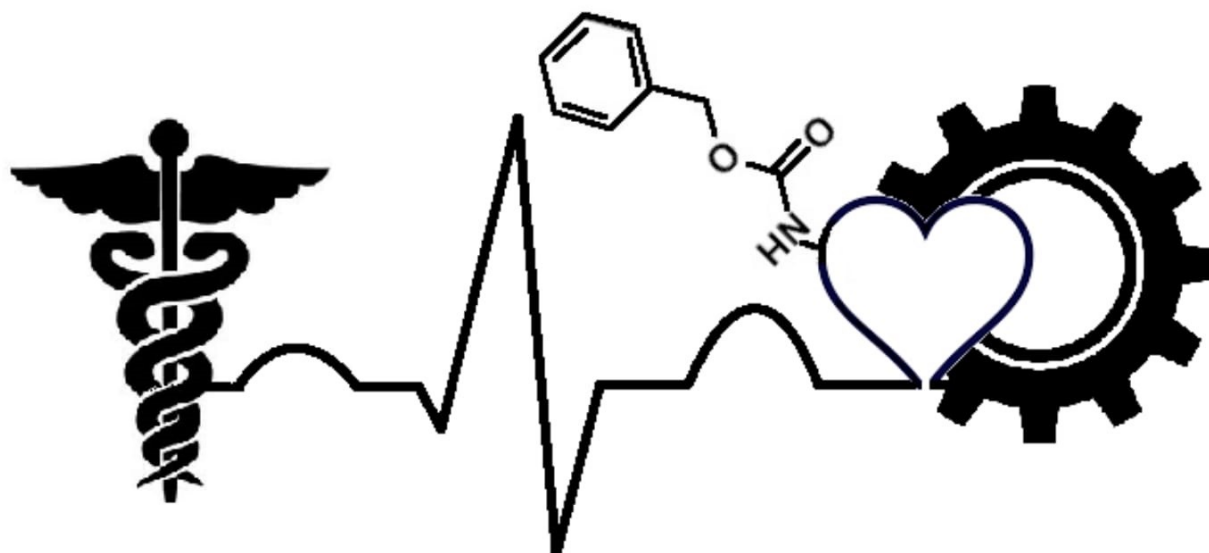
# PACS (picture archiving and communication systém)

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- Aplikace pro ukládání a čtení obrazových dat.
- Využívá jednotný formát DICOM (digital imaging and communications in medicine)
- DICOM
  - Datový standard pro přenos biomedicínských dat
  - Obsahuje kromě samotných obrazových dat ve svém těle i hlavičku identifikující pacienta

| DICOM Tag (Group, Element) | Field Name                     | Used For           |
|----------------------------|--------------------------------|--------------------|
| (0008,0031)                | Series time                    | Decay correction   |
| (0008,0032)                | Acquisition time               | Decay correction   |
| (0010,0040)                | Patient sex                    | SUV lean body mass |
| (0010,1020)                | Patient size                   | SUV lean body mass |
| (0010,1030)                | Patient weight                 | SUV                |
| (0018,1072)                | Radiopharmaceutical start time | Decay correction   |
| (0018,1074)                | Radionuclide total dose        | SUV                |
| (0018,1075)                | Radionuclide half-life         | Decay correction   |
| (0054,1102)                | Decay correction               | Decay correction   |
| (0054,1300)                | Frame reference time           | Decay correction   |
| (0054,1321)                | Decay factor                   | Decay correction   |
| (7053,1000)                | SUV factor                     | SUV (Philips only) |

Note that these are relevant for images acquired by GE or Siemens PET/CT scanners. Other necessary information (e.g., tracer activity) is contained in private fields that are determined by each manufacturer. Philips PET/CT scanners use the private field (7053,1000): SUV Factor only.



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