INTERNÍ KARDIOLOGICKÁ KLINIKA FN BRNO a LF MU

BIORESORBOVATELNÁ KARDIOSTIMULAČNÍ TECHNIKA

XXXI. Výroční sjezd ČKS, 9. 5. – 16. 5. 2023, Brno

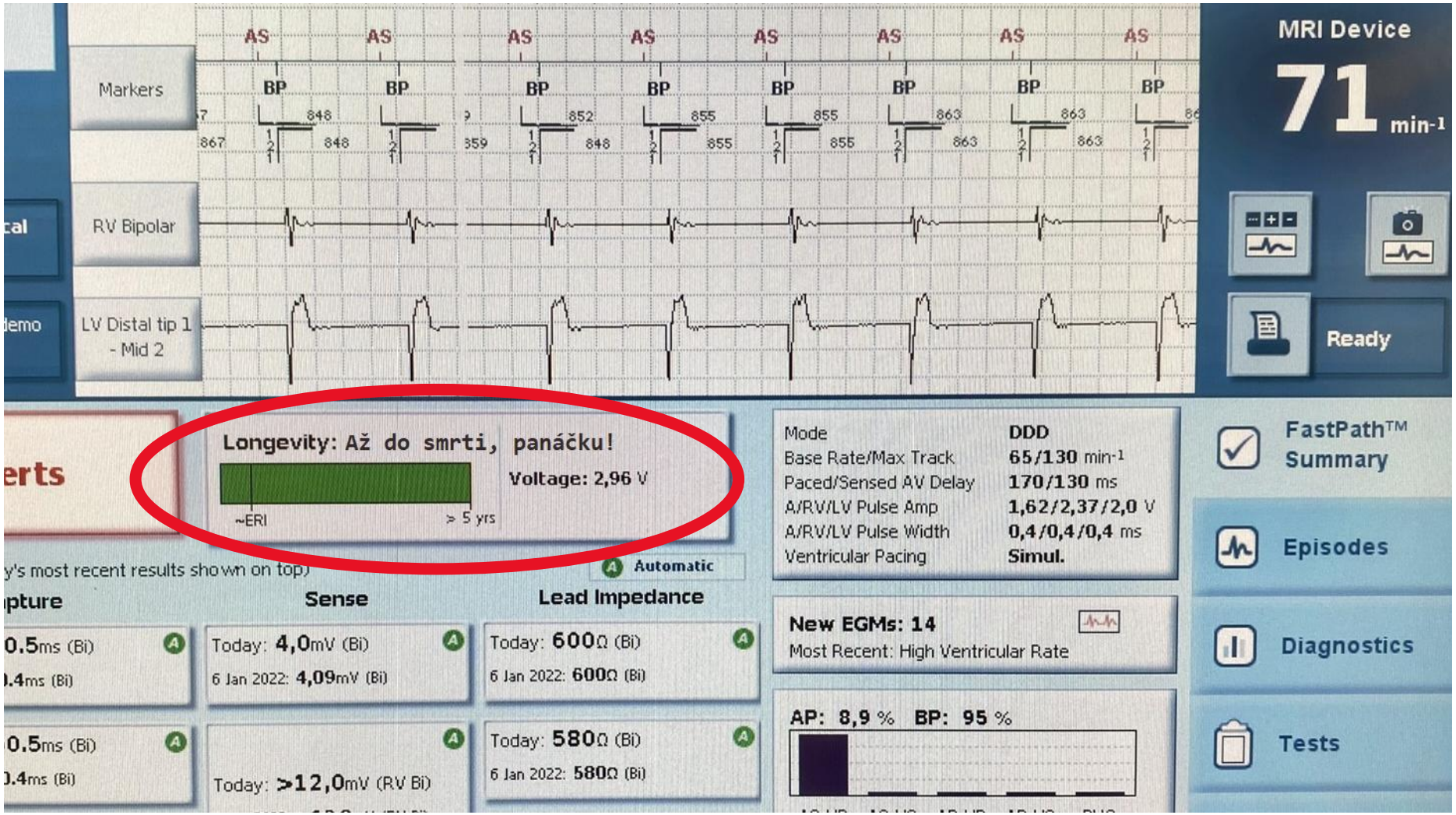
David Pospíšil

Podpořeno MZ ČR – RVO (FNBr, 65269705)

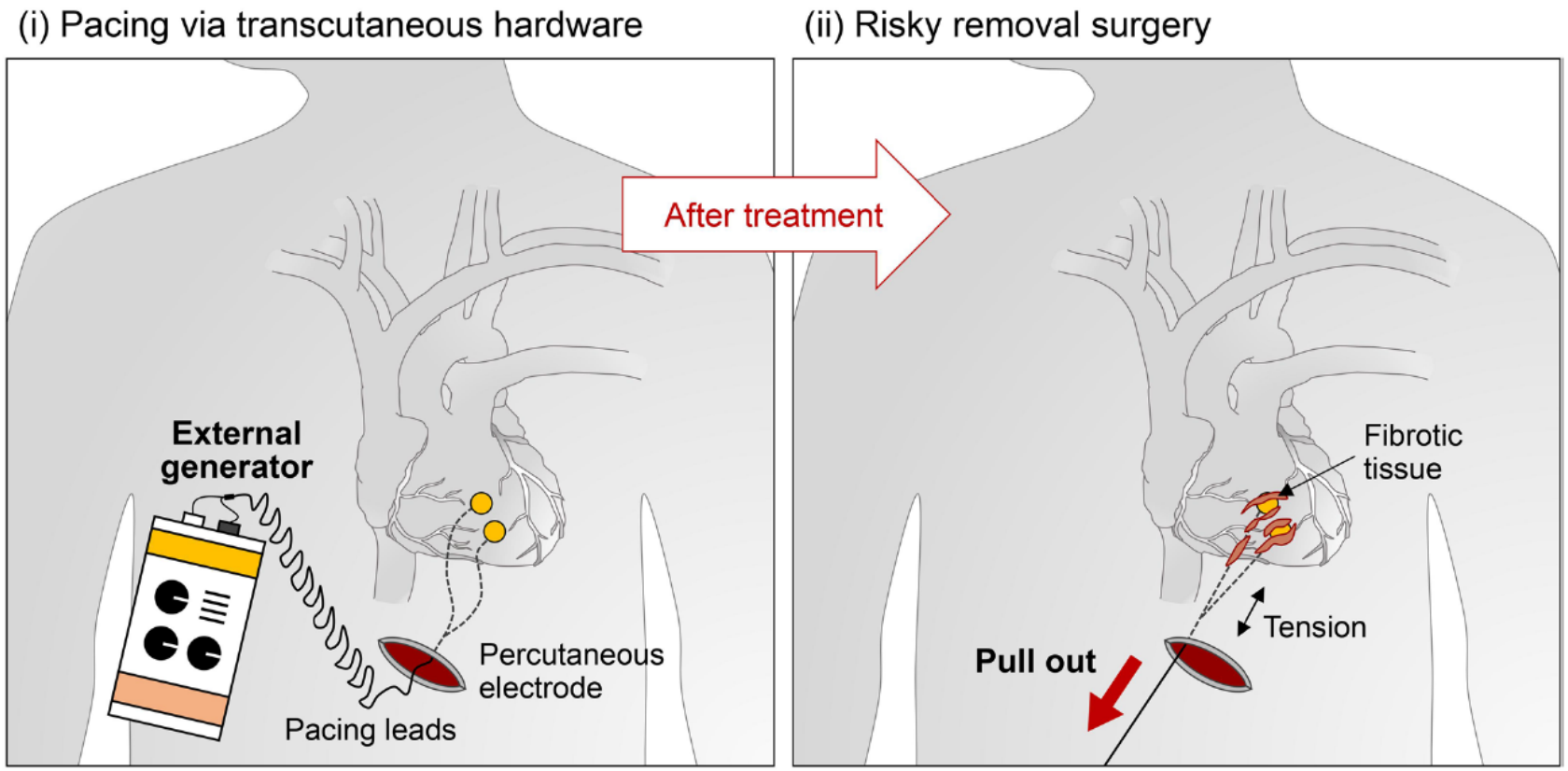
FAKULTNÍ NEMOCNICE BRNO

MUNI MED

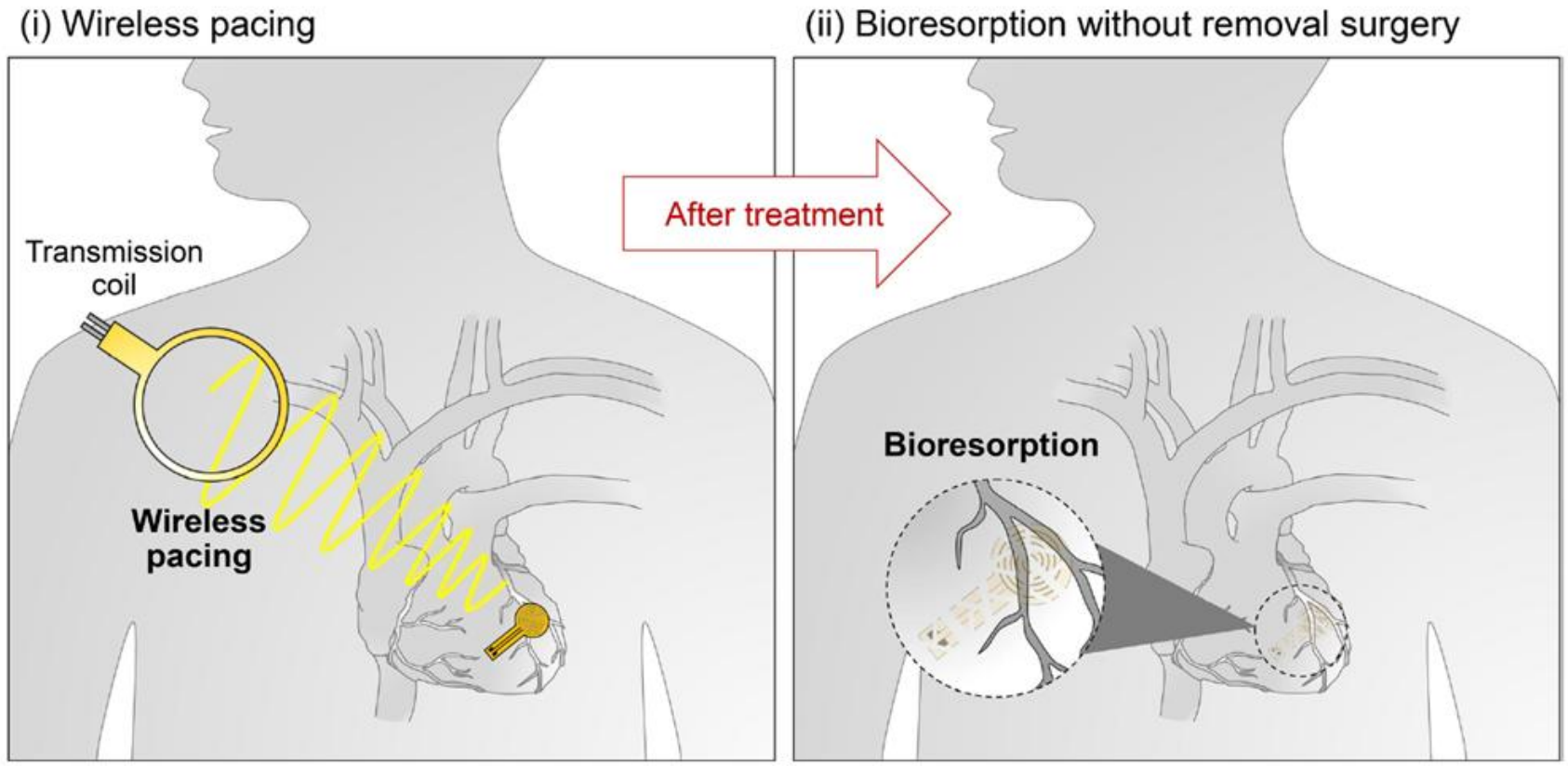
Já myslel, že chceme, aby kardiostimulátor vydržel co nejdéle!?



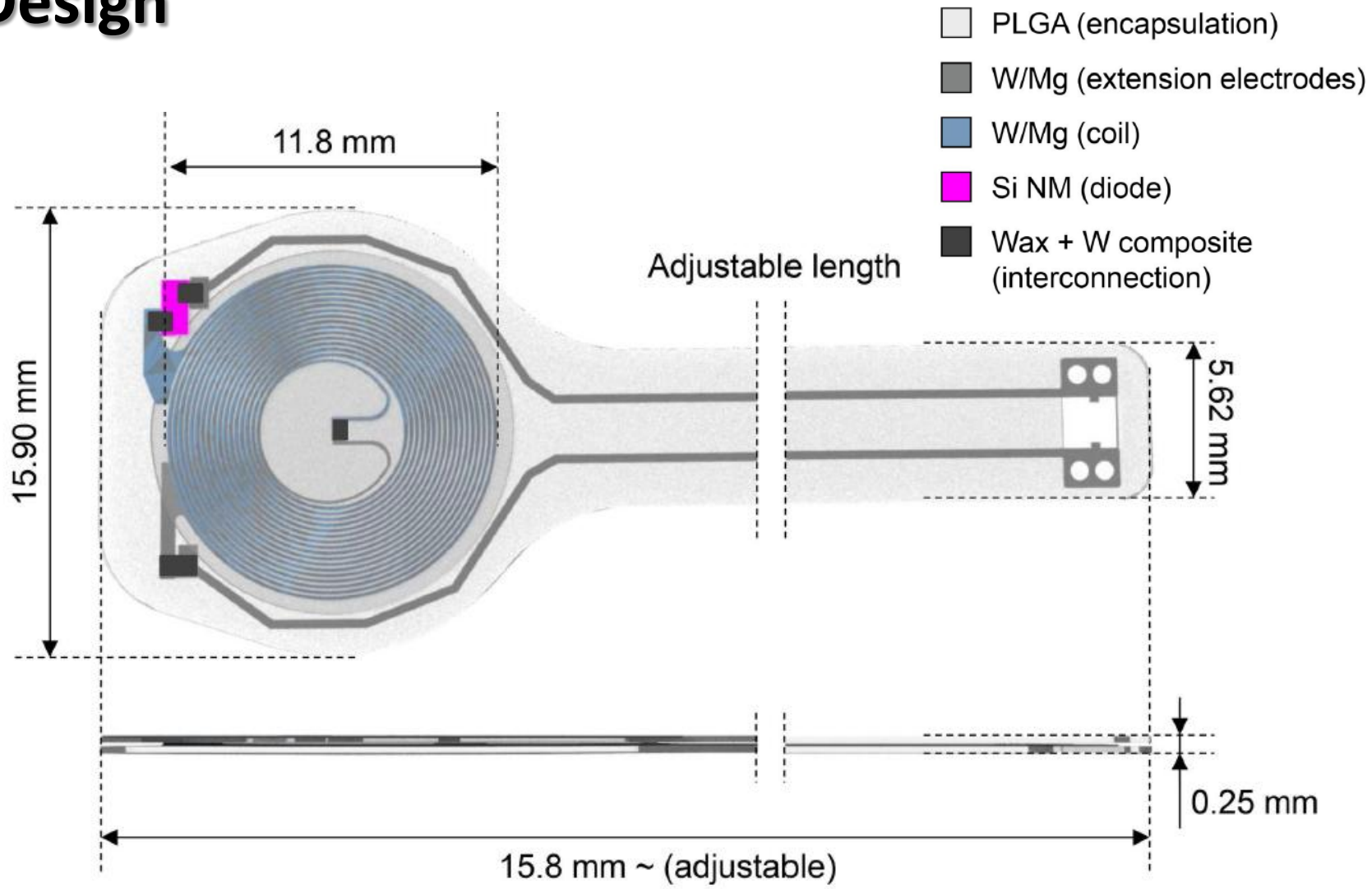
Jak se to dělá dnes?



A jak by mohlo zítra?



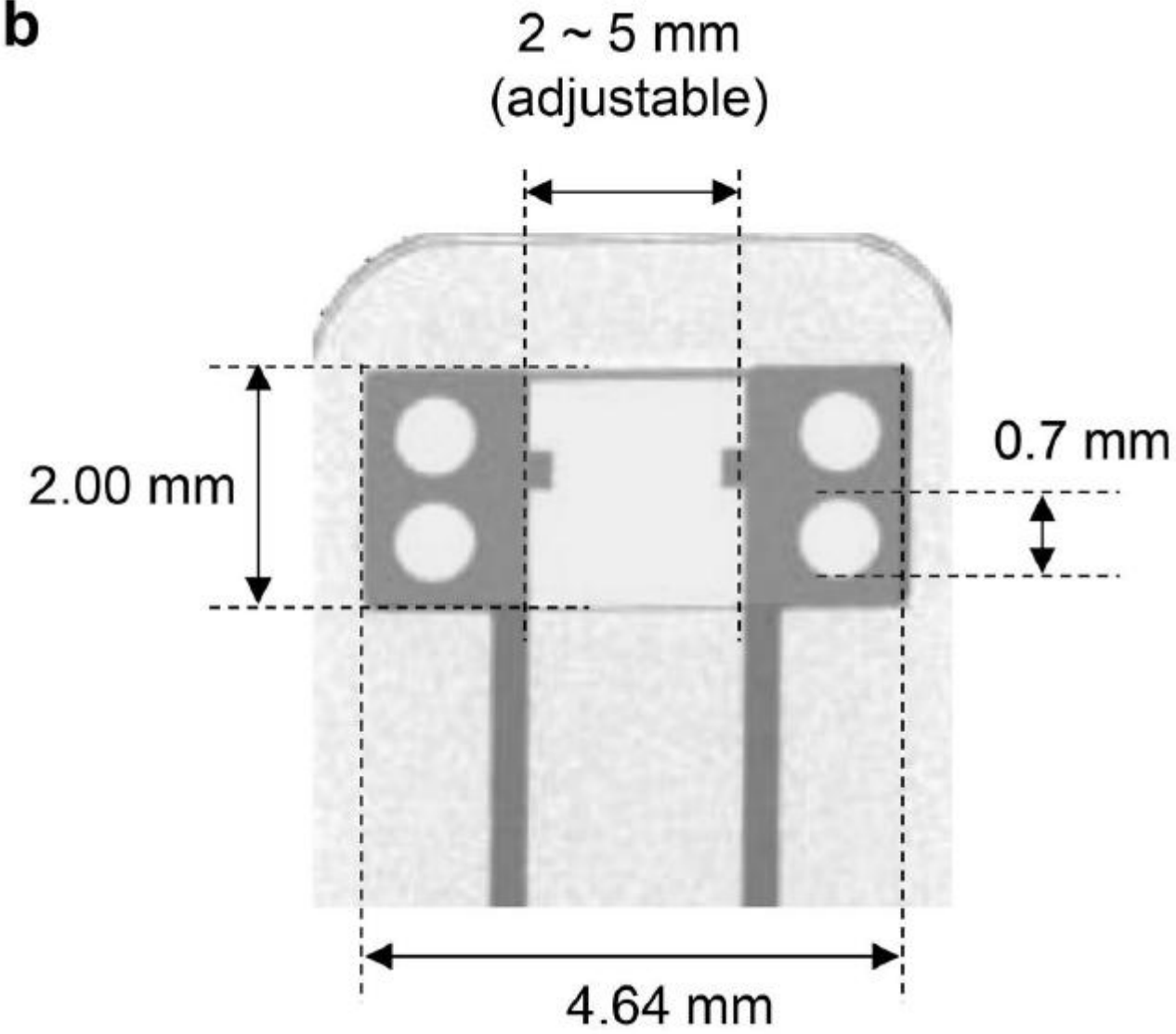
Design



- 2 metalic poles – W/Mg
  ~ 700nm /50 µm
- Coating: PLGA 65:35
- Encapsulation 100 nm
- PIN diode (Si NM)
- Electrodes: 2x 1,4mm2
- Fixation: Ethicon
- Candelillla wax + W doping

- (~0.05 ml; width ~16 mm; length >15 mm; thickness ~250 µm) and lightweight (~0.3 g)

Design



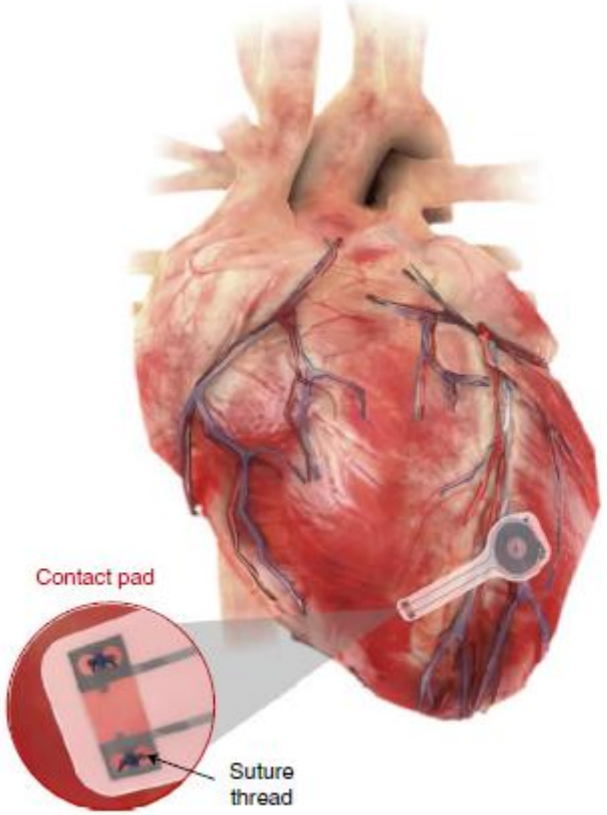
- 2 metalic poles – W/Mg
  ~ 700/50 nm
- Coating: PLGA 65:35
- Encapsulation 100 nm
- PIN diode (Si NM)
- Electrodes: 2x 1,4mm2
- Fixation: Ethicon
- Candelillla wax + W doping

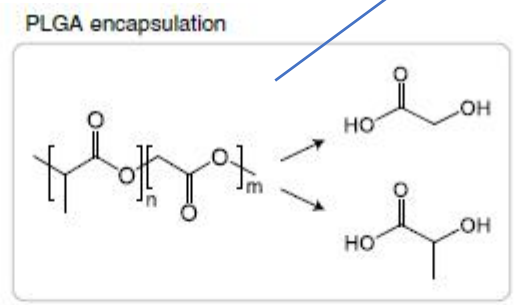
- (~0.05 ml; width ~16 mm; length >15 mm; thickness ~250 μm) and lightweight (~0.3 g)

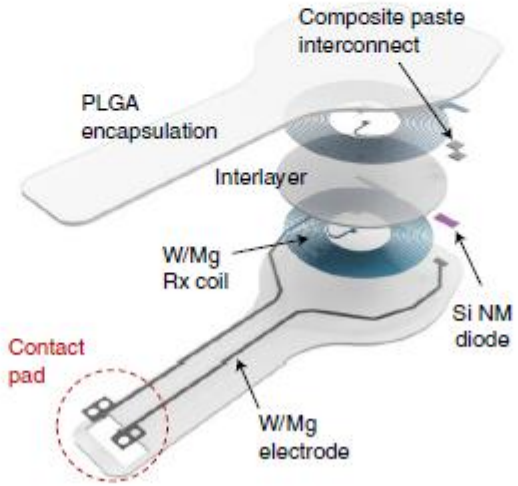
Opravdu se rozpustí?

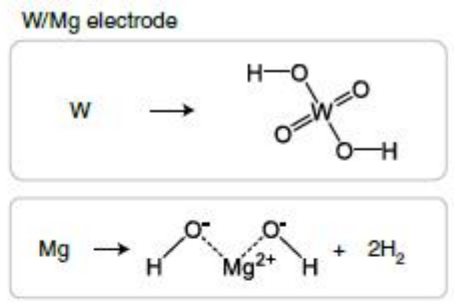
Monomery kys. glykolové a mléčné

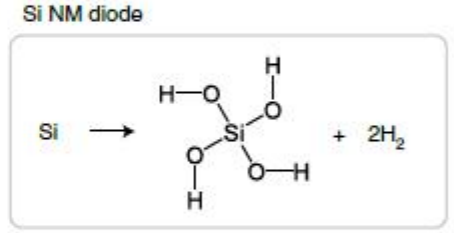
Hydrolýza se postará!

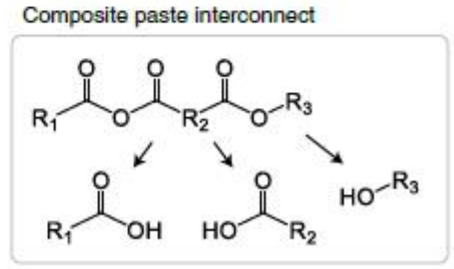












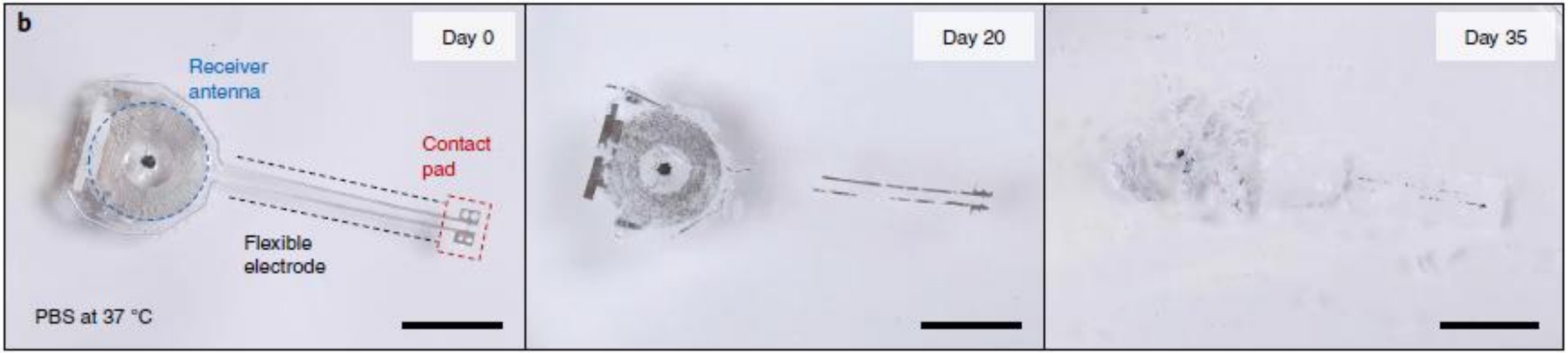
$$2\,W + 2H_2O + 3O_2 \rightarrow 2H_2WO_4$$

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

$$Si + 4H_2O \rightarrow Si(OH)_4 + 2H_2$$

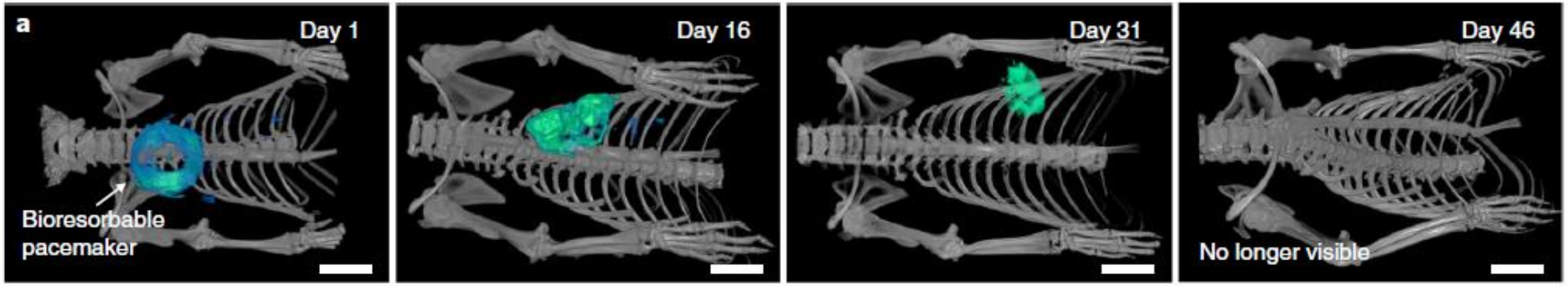
Hydrolýza…

Opravdu se rozpustí?

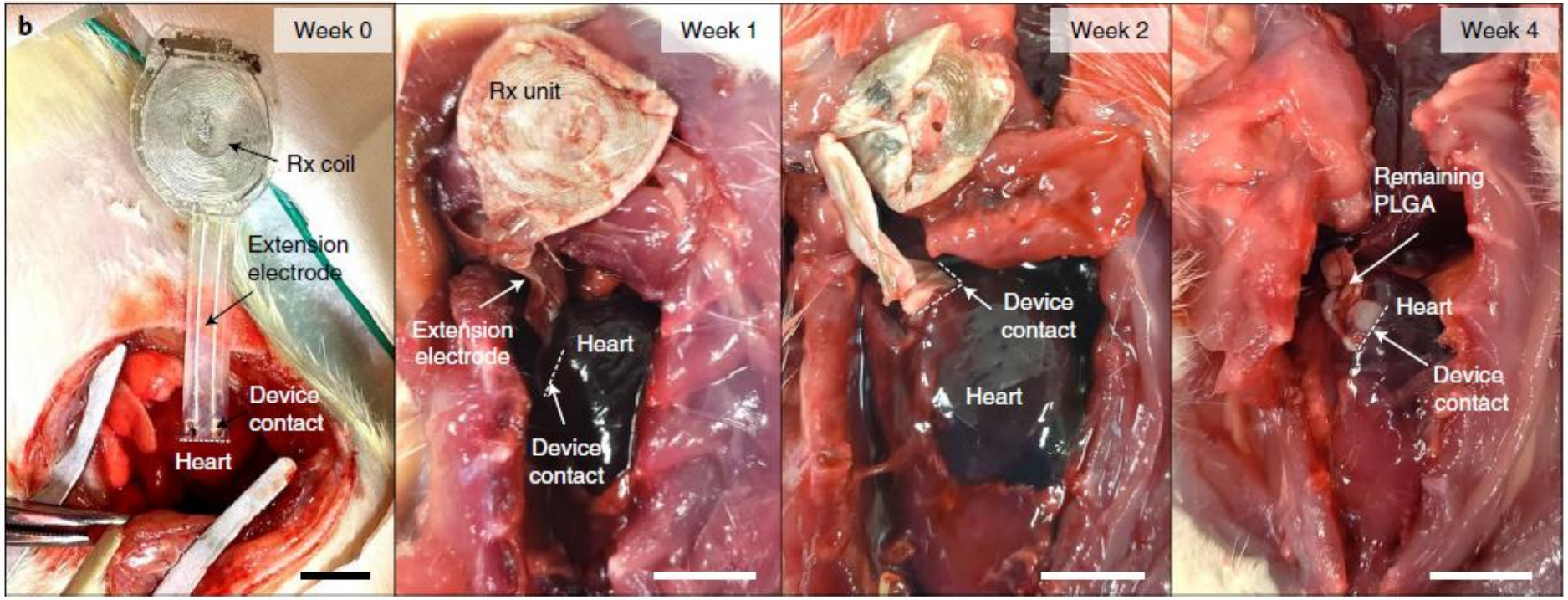


10 mm

Opravdu se rozpustí?

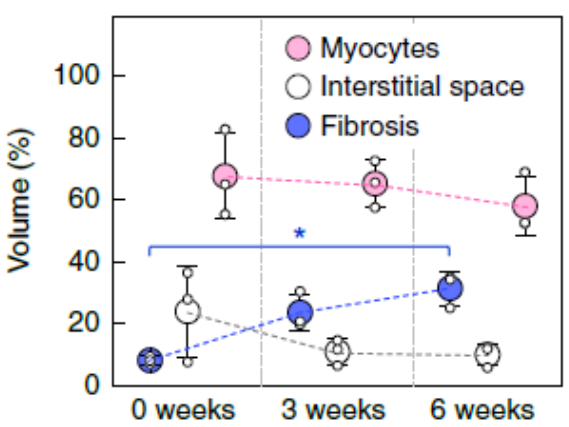


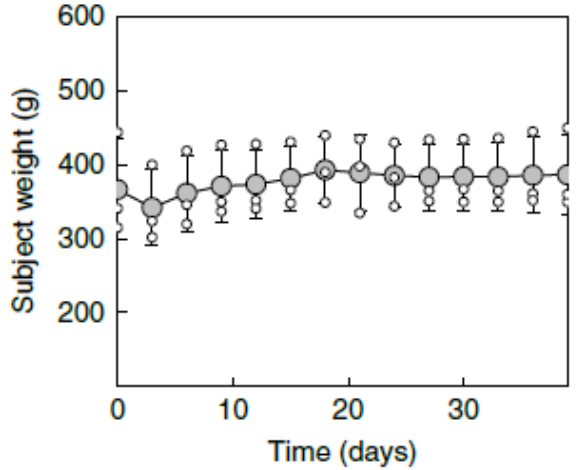
10 mm

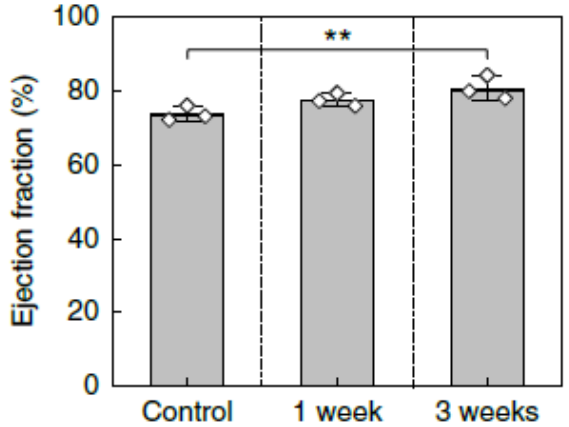


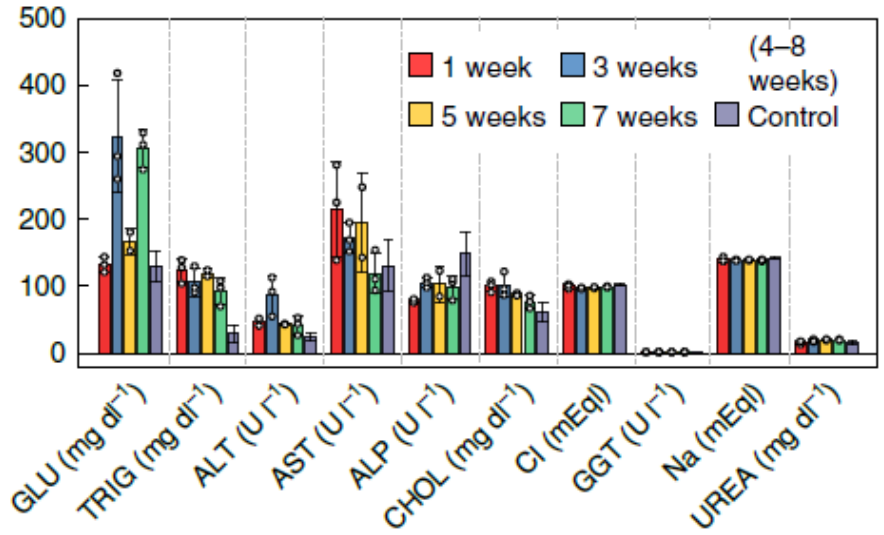
5 mm

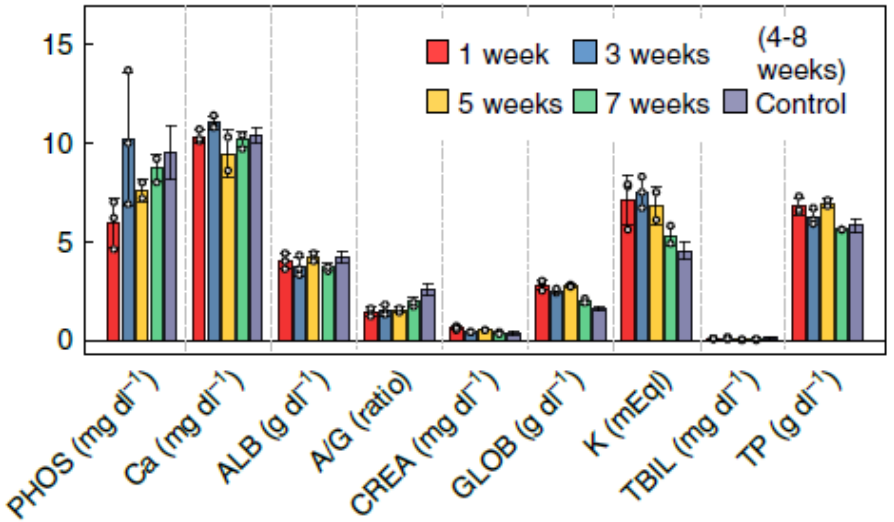
Biokompatibilita





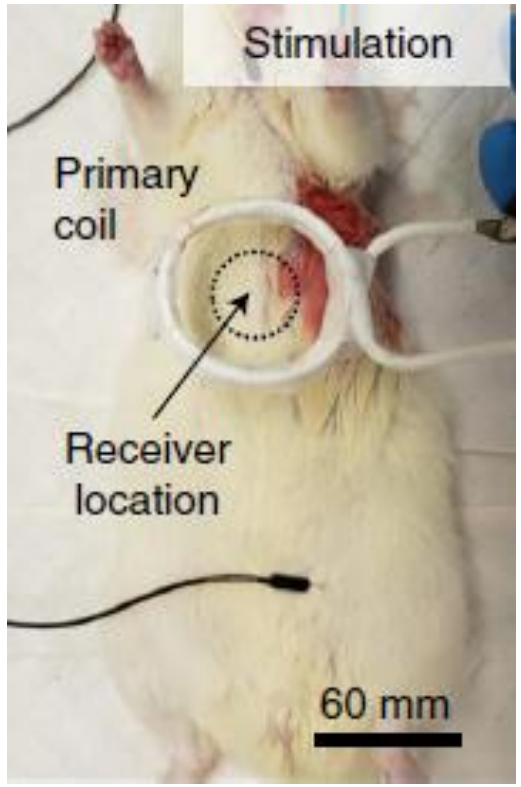




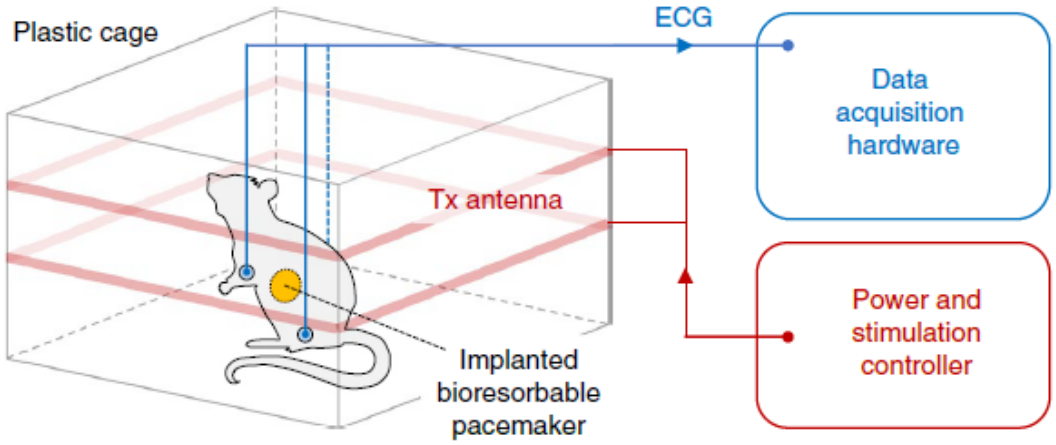


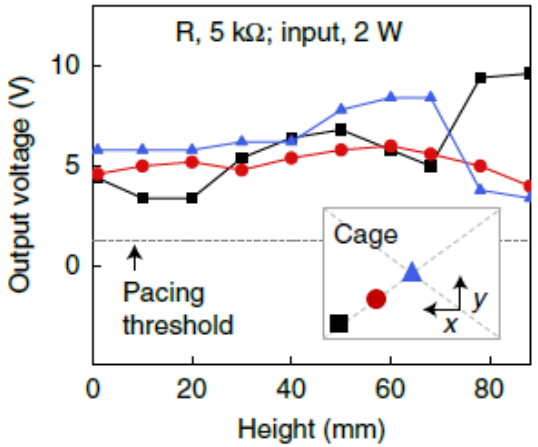
Přenos výkonu

$$M = k\sqrt{L_{Tx}L_{Rx}}$$

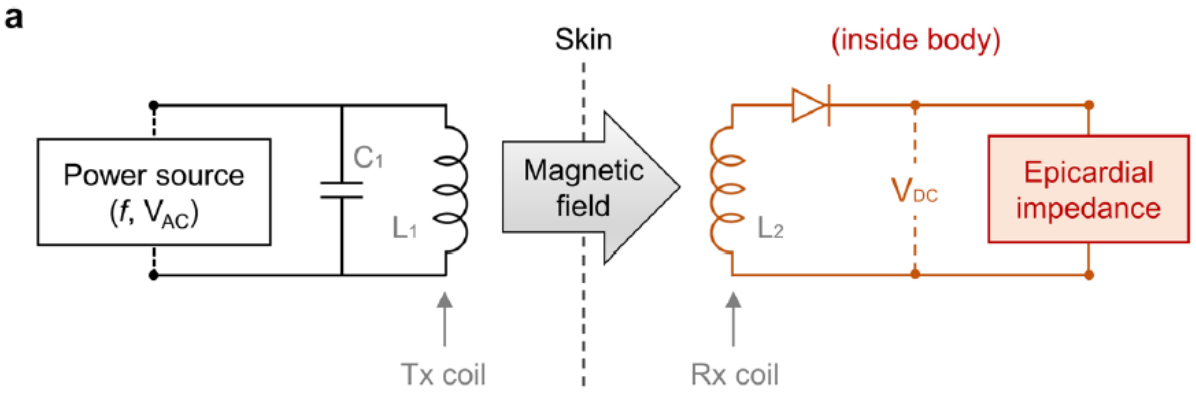


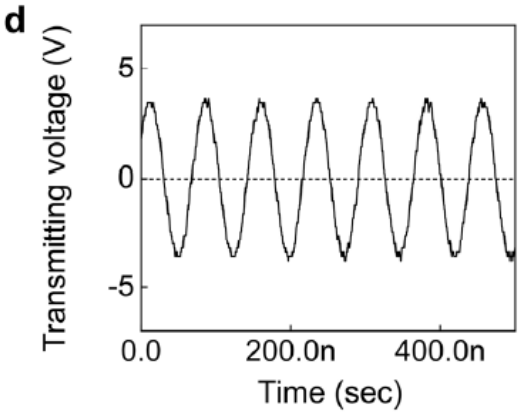
Správná konfigurace: parasternálně, 32 ± 8 mm; apikálně, 31 ± 10 mm; subkostálně, 71 ± 20 mm)

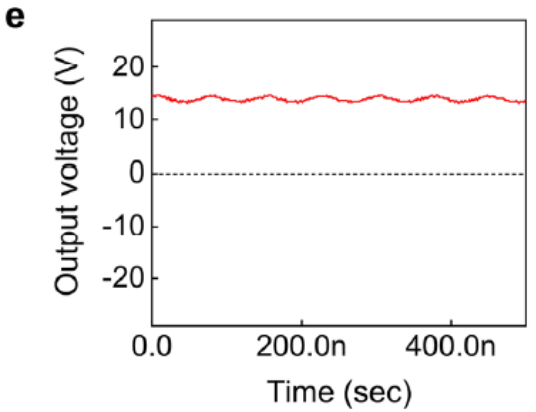


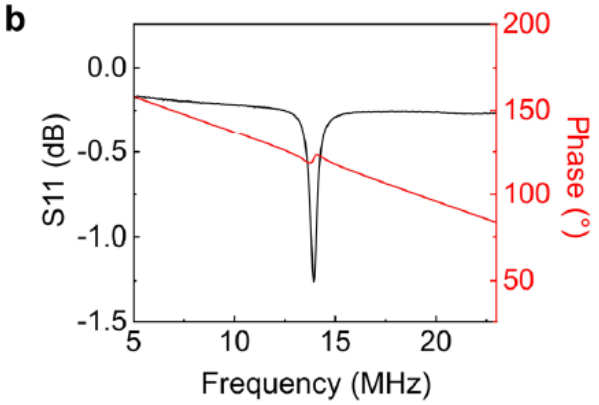


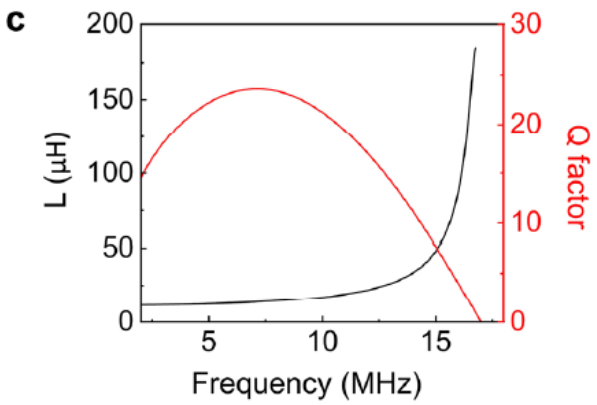
Přenos výkonu (příklad pro Tx 20mm, 3 otáčky a Rx 12mm, 17 otáček)

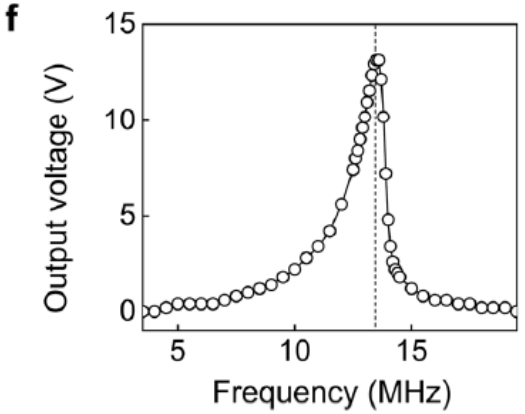


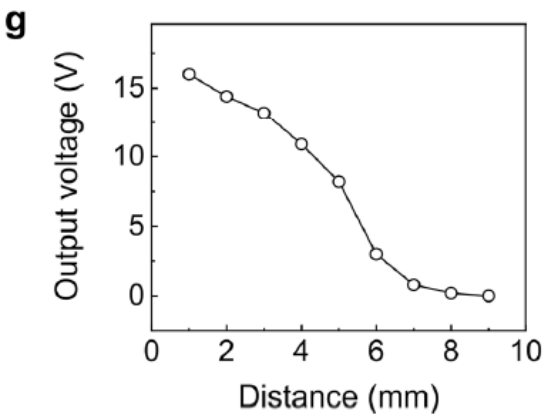




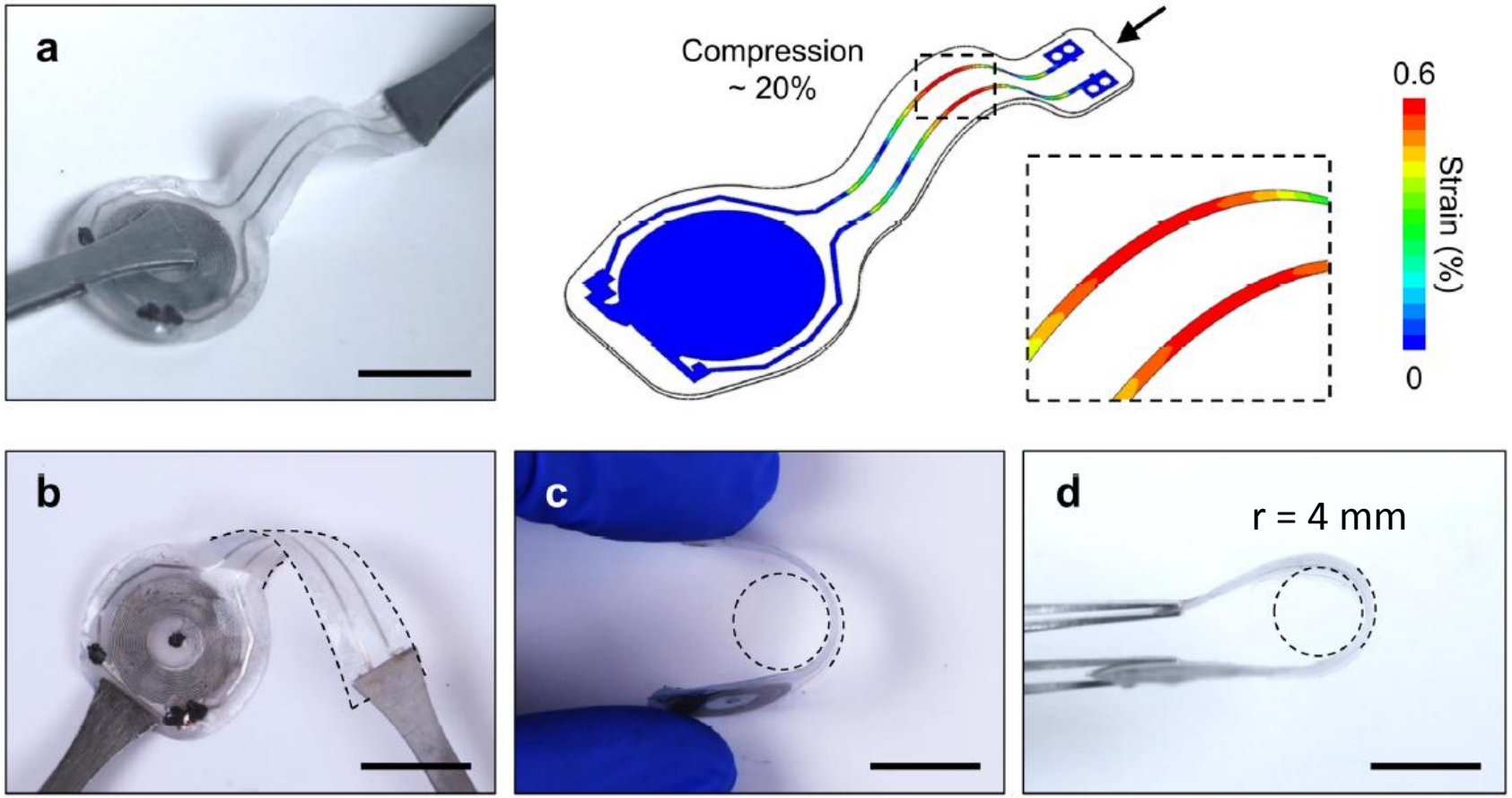




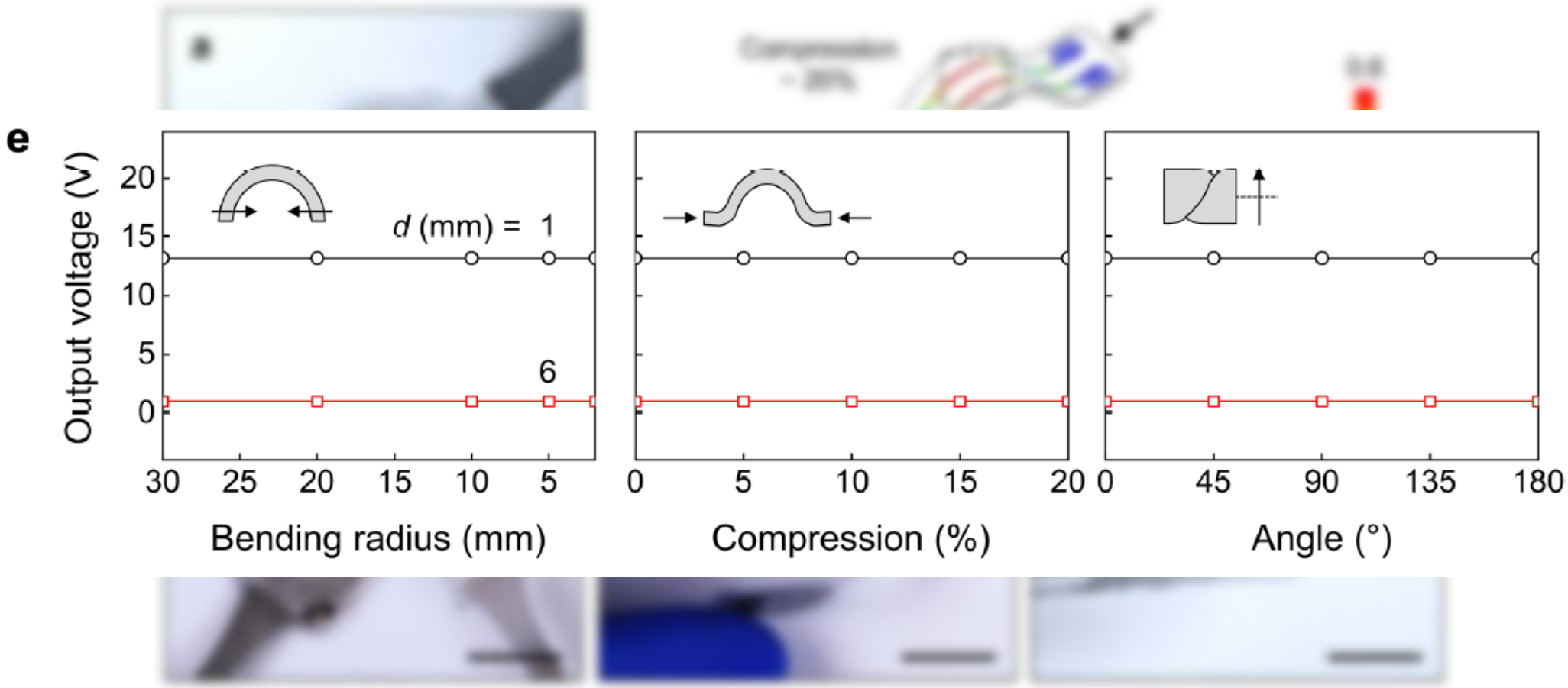




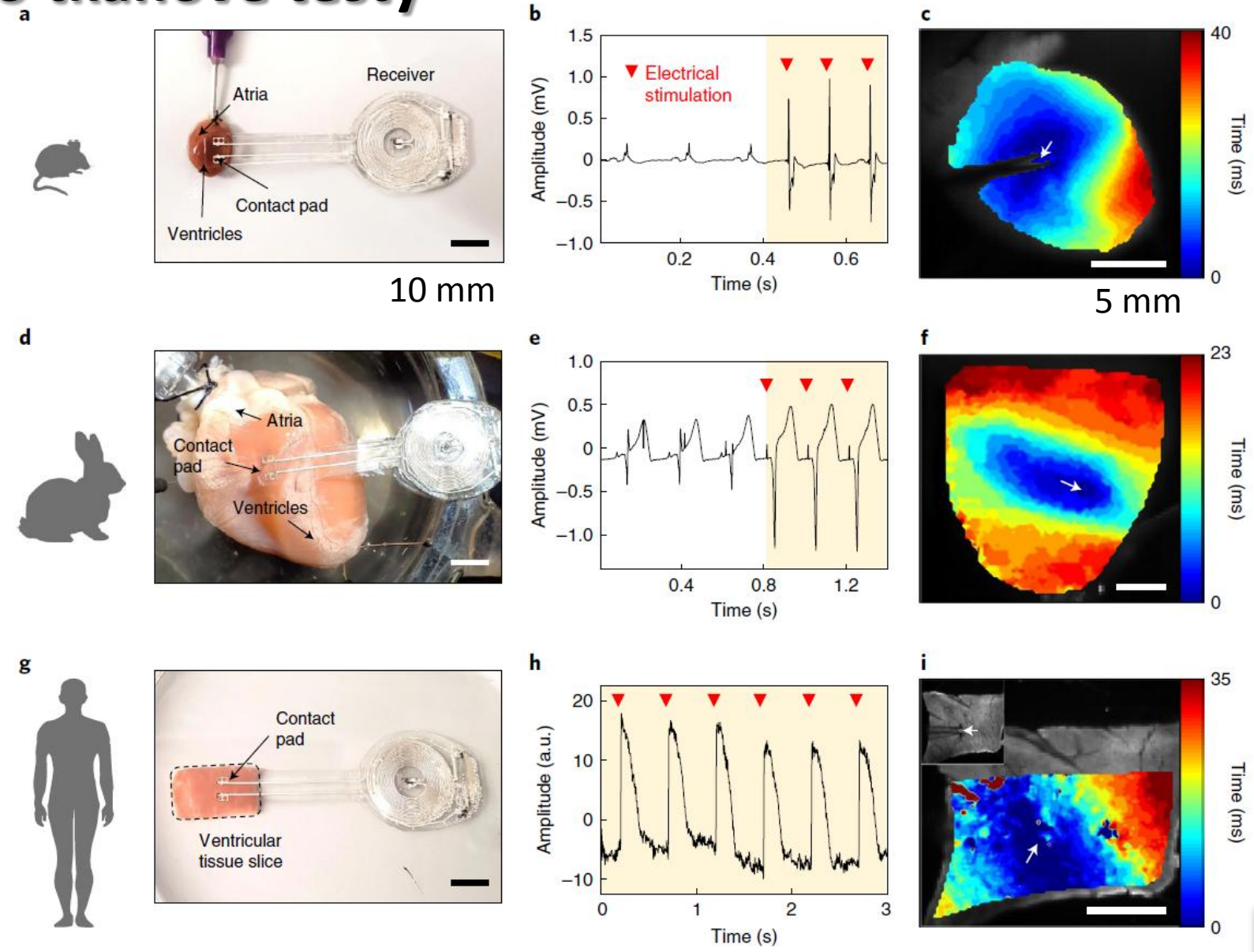
Mechanická odolnost



Mechanická odolnost

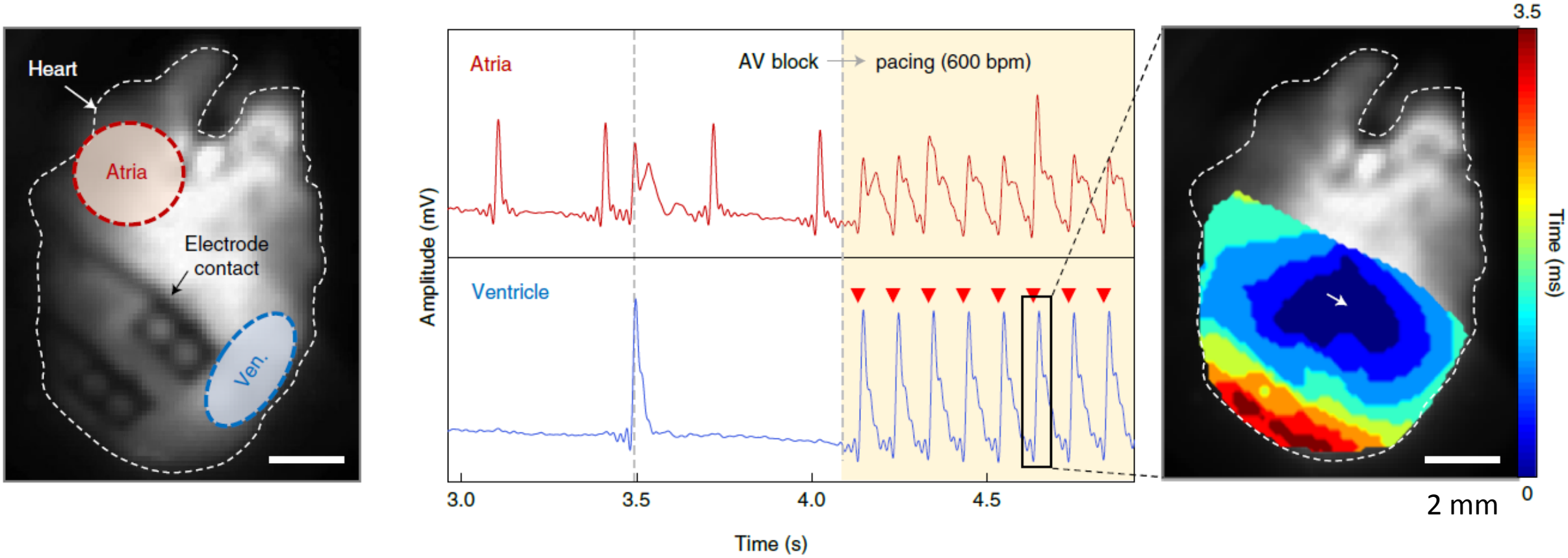


In vitro tkáňové testy

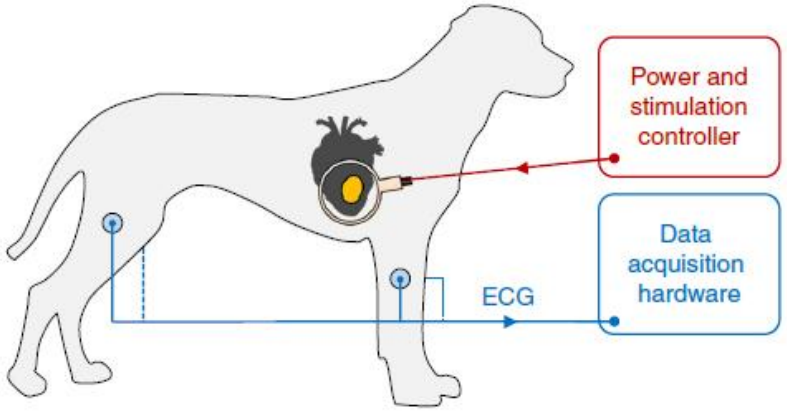


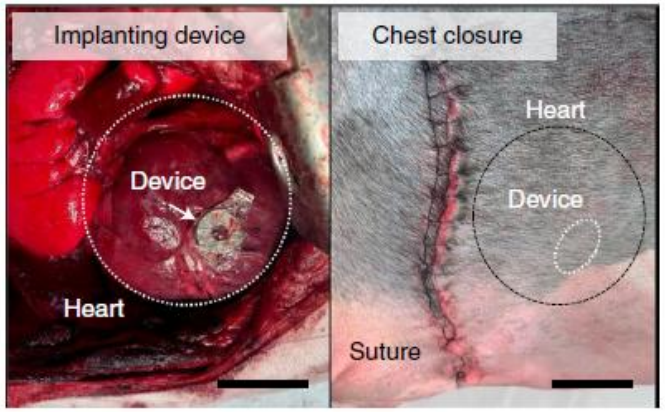
Ex vivo AV blok II. stupně (myš)

AV block treatment ex vivo Langendorff-perfused mouse model. Scale bar 2mm.

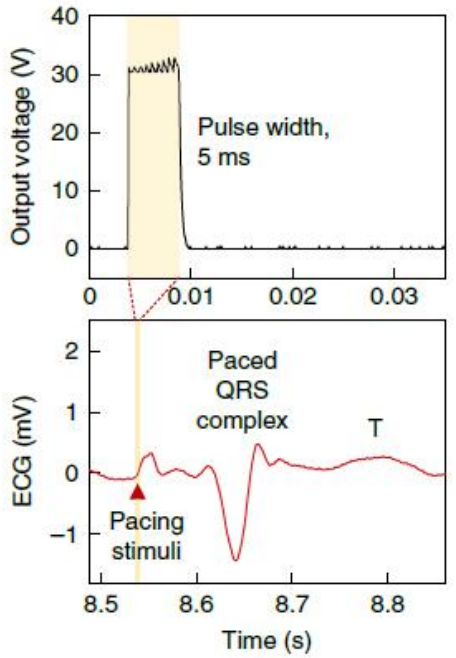


In vivo velký zvířecí model





50 mm



Na co se můžeme těšit?

Pořád je to experiment, ale…

- √ Zamezení nevýhod externí kardiostimulace s perkutánním metalickým přenosem
- √ Zamezení rizik extrakce systému
- √ Umožnuje plnou implantaci, je bezesvodový, a kompletně podlehne bioresorpci
- √ Plánování longevity
- √ Stimulační práh rostoucí v čase dosud nevídaným tempe, až do 2V den^{-1}

> “Taken together, these results establish the foundations for a bioresorbable electronics technology designed to address unmet needs in important areas of care for cardiac patients.”
>
> professors Igor R. Efimov, John A. Rogers, Rishi K. Arora, October 2021

Zajímá mě to, kde najdu další informace?

https://doi.org/10.1038/s41587-021-00948-x

https://doi.org/10.1038/s41563-021-01051-x

nature materials

ARTICLES

https://doi.org/10.1038/s41563-021-01051-x

Check for updates

Photocurable bioresorbable adhesives as functional interfaces between flexible bioelectronic devices and soft biological tissues

Quansan Yang[1,2,3,26], Tong Wei[4,26], Rose T. Yin[5,26], Mingzheng Wu[6,26], Yameng Xu[7,8,26], Jahyun Koo[9], Yeon Sik Choi[1,2,7], Zhaoqian Xie[10,11,12], Sheena W. Chen[13], Irawati Kandela[14,15], Shenglian Yao[16], Yujun Deng[3,17], Raudel Avila[3], Tzu-Li Liu[3], Wubin Bai[1,2,7,18], Yiyuan Yang[1,2,3], Mengdi Han[1,2], Qihui Zhang[7], Chad R. Haney[15,19,20], K. Benjamin Lee[13], Kedar Aras[5], Tong Wang[4], Min-Ho Seo[1,2,7,21], Haiwen Luan[1,2,3], Seung Min Lee[7], Anlil Brikha[15,19], Nayereh Ghoreishi-Haack[14], Lori Tran[14,15], Iwona Stepien[14,15], Fraser Aird[15], Emily A. Waters[15,19,20], Xinge Yu[22], Anthony Banks[1,2], Gregory D. Trachiotis[5,23], John M. Torkelson[4,7], Yonggang Huang[1,3,7,24], Yevgenia Kozorovitskiy[6,15] ✉, Igor R. Efimov[5] ✉ and John A. Rogers[1,2,3,7,20,25] ✉

ARTICLES

https://doi.org/10.1038/s41587-021-00948-x

nature biotechnology

Check for updates

Fully implantable and bioresorbable cardiac pacemakers without leads or batteries

Yeon Sik Choi[1,2,3,24], Rose T. Yin[4,24], Anna Pfenniger[5,24], Jahyun Koo[1,2,24], Raudel Avila[6], K. Benjamin Lee[7], Sheena W. Chen[7], Geumbee Lee[1,2,3], Gang Li[8], Yun Qiao[4], Alejandro Murillo-Berlioz[9], Alexi Kiss[10,11], Shuling Han[12,13], Seung Min Lee[1], Chenhang Li[6], Zhaoqian Xie[14], Yu-Yu Chen[15], Amy Burrell[5], Beth Geist[5], Hyoyoung Jeong[1,2], Joohee Kim[1,2], Hong-Joon Yoon[1,2,3,16], Anthony Banks[1,2], Seung-Kyun Kang[17,18], Zheng Jenny Zhang[12,13], Chad R. Haney[19,20], Alan Varteres Sahakian[19,21], David Johnson[5], Tatiana Efimova[10,11], Yonggang Huang[1,3,6,22], Gregory D. Trachiotis[9], Bradley P. Knight[5], Rishi K. Arora[5] ✉, Igor R. Efimov[4] ✉ and John A. Rogers[1,2,3,6,19,23] ✉